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AMERICA, ENGLAND, AND GERMANY AS ALLIES FOR THE OPEN DOOR.

By Hon. John Barrett, late U. S. Minister to Siam.

I.—IDENTITY OF INTERESTS DICTATING A UNITY OF POLICY.

AMERICA, England, and Germany have it in their power, by united action, to preserve the integrity of the Chinese Empire, and to maintain forever the freedom of trade throughout her entire extent from Kwangtung to Manchuria and from Kiangsu to Szechuan. Whether they will take advantage of this mighty responsibility remains to be seen. The fact that they have this power is not fully appreciated. The heads of these respective governments may be willing to pursue a strong joint policy in China, but that the people themselves are ready to support them is not yet proved. The work of education must go on.

In England and in Germany there is a more prevailing tendency to uphold their governments in a Chinese policy than in America, but in Germany the interests at stake do not yet fully understand the situation. In Great Britain the people are even more earnest than the Foreign Office in their advocacy of the protection of their rights; while Americans from New York to San Francisco should favor a vigorous attitude on the part of the government in China because all sections of the country are deeply concerned in keeping open a vast field of trade which Americans have only begun to exploit. Amer-

The acquirement, by the United States, of interests in the far east is the most certainly fruitful event of modern times. It means that America will henceforth extend her industries—and hence her politics—along lines parallel with those run by Great Britain and Germany. The Hon. John Barrett, for many years an observant student and traveler in China, Japan, and the Philippines, and for four years United States Minister to Siam, speaks as one having authority. His arguments, addressed to the engineering world whose interest is first and greatest, should be forceful in awakening a true appreciation of the merits of the case and in shaping that popular opinion which is the mainspring and the controller of the action of all representative governments. THE EDITORS.

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ican manufacturing industries and shipping interests have so developed that the United States are now able to export manufactured and natural products to China and compete successfully with the two other great industrial nations of the world, England and Germany.

These two countries, while recognizing the position that America is taking as a competitor for the world's trade, believe that they are able to hold their own, and are willing to start with her in an even race for the profits of the markets of China. Although America has a protective tariff for her home industries, there is no complaint among her manufacturers and exporters that, in the major proportion of the articles sent to China, they are not able to compete successfully with England, Germany, and other nations. Whether this capability of competition is due to the perfection of manufacturing, favorable shipping rates, or enterprise of exploitation, the fact exists. This enables the American who is concerned in the commerce of China to join hands, as it were, with his brother trader of Great Britain and Germany in protecting and extending the markets of Asia.

If the policy of Germany in Shantung were studied, it would be found that the position she occupies there is inspired by ambitions of empire and power, more than by demands of her manufacturers and exporters that they have an exclusive field. The German manufacturer and his agent in Asiatic ports know that he needs no discriminating tariff in order to compete in the markets of the Orient. In the same way, England's position at Hong Kong, Singapore, and Wei-hei-Wei finds its inspiration in her desire to be a world power and to be able everywhere to protect her great and growing interests. The manufacturers and exporters of England realize the importance and value of the possession of such strategic points, but you seldom hear them making any complaint on the point of competition where they have equal rights of trade with the merchants of other nations.

Thus we have a situation which is peculiarly favorable to the harmonious working of America, England, and Germany for the preservation of the integrity of China and the maintainance of the "open door" throughout her great area. Each power has guaranteed to it by the Tien Tsin treaties no limitations of its commercial rights. If they insist, through all conditions, that those treaties shall not be abrogated or infringed, their merchants, capitalists, and investors, as well as manufacturers and engineers, need have no fear as to the future. A generous rivalry now exists throughout the world between these three powers for the increase of their foreign exports. If they realize

what they have to gain in China by keeping her intact, and what they have to lose by her division, they may be forced to take a position which will enable them to protect what they already have and provide for an unlimited extension in the future.

FIELD FOR COMMERCE AND ENGINEERING.

Among China's uncounted millions and in her wide area is a market for the surplus product of all these countries. I do not mean that this market would consume their surplus were all other foreign markets cut off, but with the growing demands of South America, South Africa, and other portions of Asia, Europe, and America, there is in China a greater undeveloped field than in any other of the countries named. In other words, China has the largest specific market, whose limit has not yet been reached, of any important section of the world.

With the commercial exploitation of China's area and people must come that imperative demand for the skill of the engineer and for the products of his hand as well as those of the manufacturer. Wherever commerce goes, there follows the necessity of the engineer's presence.

It is no exaggeration to state that the engineers of the world can now see before them in Asia, and in China in particular, more manifold opportunities for their work than in any other portion of the world where material progress has only begun its mighty undertakings. Engineering projects of all kinds go hand in hand with commercial expansion. Wherever the manufacturer, the exporter, or the missionary goes, whether in person or through his labors, there will presently be a demand for the engineer. The articles of trade which penetrate into the innermost parts of China and other Asiatic lands are only the forerunners of greater developments that follow. They are the initial influences that lead to great movements, and no great movement now is accomplished without the aid of the engineer, as well as that of the merchant and diplomatist. The more one travels, not only through China, but through Japan, Corea, Eastern Siberia, Indo-China, Siam, Malay Peninsula, Java, Borneo, Formosa, and the Philippines, the more is he convinced that their future progress and prosperity depend, perhaps, more upon the engineer than upon the exporter, manufacturer, merchant, missionary, and diplomatist. Although my experience has been largely in diplomacy, what I have repeatedly seen has convinced me that the engineer is perhaps to-day the most essential personal element in the development of these unknown Asiatic countries. He will act and be successful where the di-

plomatist, missionary, and business man fail. There is an eminently practical side to his efforts which is beginning to appeal to the easy-going nature of the Asiatic. A decade or more ago the Asiatic despised and hated the engineer and everything connected with him, but now he is beginning to realize what advantages, changes, happiness, and comfort this most remarkable of all varieties of foreigners can accomplish. He may rise up at first in opposition to the engineer's plans and his works, even destroying them, but in time he recognizes his mistake and loves the man whom before he has distrusted, taking advantage of all his devices and using them as if he had been accustomed to them by the habit of centuries.

When the Chinese cast the first railway from Shanghai to Woosung into the river, they were only preparing themselves for a network of railways all over China. When the Coreans in Seoul destroyed the new electric line in that city and burned the cars, they were only having a serious celebration prior to a happy acceptance of this new method of locomotion in which they would crowd these radical means of conveyance and bring good dividends to the stockholders. After the Siamese had looked at the wondrous movements of the first electric railway that ran through the great city of Bangkok, they muttered a few complaints about its speeding along too rapidly and not giving them sufficient time for rest, and then concluded that it was the best scheme for saving extra exertion in walking which their crude minds had ever conceived! The engineer should have little fear as to the ultimate success of his enterprises in Asia. The field is so wide and the rewards so tempting that all of the engineers of the United States, England, and Germany should be arrayed in support of a policy which will protect and develop the utilization of their talents throughout all China.

PERSONAL STUDY OF THE FIELD.

That those who are good enough to read this article—which I have consented to write only at the earnest solicitation of the Editor—may understand why I am so earnest in regard to the Asiatic opportunity, I may possibly be pardoned for referring to my personal study of the far east. Appointed United States Minister to Siam in the early part of 1894, where I was sent to settle the long standing Cheek case, I devoted my leaves of absence to traveling through the principal countries of eastern Asia, studying both material and political conditions. The reach of my investigations extended from Batavia, Singapore, and Bangkok on the south, to Peking, Vladivostock, and Tokio on the north, including frequent visits to Manila, Hong Kong,

Canton, Shanghai, Hankow, Tien Tsin, Chemulpho, Kobe, and Yokohama. Not contented with visiting the coast ports, I more than once found my way to distant interior points. In short, my observations are based on over five years' careful observations of the principal countries and cities of eastern Asia, both in a diplomatic and private capacity. When I left my post of duty at Bangkok in 1898, I went directly to Manila by courtesy of Admiral Dewey soon after his great victory, and remained there off and on for nearly a year, through war, peace, and war again, until this last March when personal matters in America required my return,

It is not my desire by this reference to personal experience to exaggerate in any way the importance of my own opinions, or to call attention in the slightest degree to my own achievements or record. My simple purpose is to show to the majority of the readers of THE ENGINEERING MAGAZINE, who may not be familiar with my association with Asiatic matters, that I am not basing my conclusions on the opinions of others or upon a study of the field made through long-distance glasses. There are, moreover, many who are far better authorities than I can hope or claim to be. If they differ from me, I trust that they will at least give me credit for sincerity. It is not to be expected that my humble opinions will coincide with those of all students of the far east, or that theirs will agree with mine. The field is so vast and the policies to be pursued in its development have so many bearings that it would be remarkable if all authorities were in accord. I have great respect for the judgment of those who are opposed to my inferences, and I trust that they will reciprocate the sentiment.

THE INFLUENCE OF NATIONS.

Commerce is the lifeblood of nations. It is the strong, virile element of progress that gives force to moral power. Without vast trade interests, it is impossible for a country to exercise a vigorous political influence throughout the world. Whenever a new field of commercial expansion is being opened to the competition of all nations, it should be the one purpose of those which control the major portion of the world's trade to see that it is never closed. Countries which have nothing to lose by limiting the extent of Asiatic markets will direct their energies to dividing up the territory concerned; it should, therefore, be the policy of those which have everything to gain, by enlarging such areas of exploitation, not only to keep them free and unrestricted to all competitors, but to prevent the impending division.

America, England, and Germany, as the three leading industrial nations, easily outstrip all others. They have taken the first three positions in the line of the world's competition, and will probably hold them at least for the next half century. What combinations or sweeping changes may be effected in the meantime no one can safely foretell, but the living indications point to Anglo-Saxon and Teutonic supremacy in the material and political struggle of the principal powers.

France, Austria, Italy, and Spain can never hope to outstrip Germany or England. Russia, the only remaining power that can be considered in this comparison, is largely an unknown quantity. From past experience and from present conditions it might be said that she is not destined to be a dangerous competitor in the race for commercial leadership, unless she is able to control the great markets of Asia by breaking down the Tien Tsin treaties, developing spheres of influence, and granting discriminating rates over her Trans-Siberian railway. This she will not be able to do if England, Germany, and America unite to prevent such eventualities, nor will she herself endeavor to carry out this policy if she sees a strong combination against her, and may even unite with them to preserve the integrity of the Chinese Empire and the full meaning of the treaties. Japan, which must not be overlooked in the rating of commercial nations, is, fortunately, in line with the policy of America and England, and can be considered as a reserve force strengthening their position. Right at hand, in front of the very doors of China, she is an influence for good that must not be forgotten. She may be developing into an important competitor, but the more Japan develops, the greater seem to grow her demands for products of other countries, so that Europe and America have not yet cause for serious apprehension of Japanese competition. The new treaties coming into force in Japan, which make her for the first time in history a first class power in every respect, are destined to enlarge the field for the export of foreign products and for the investment of foreign capital.

THE FIELD IMPORTANT AND PECULIAR.

When I contend that China stands to-day with the greatest latent possibilities for foreign commercial, financial, and engineering exploitation, and that no part of South America or South Africa holds out such inviting opportunities, I mean that, while large portions of these continents may be undeveloped, wild, and possessed of splendid material riches, they have not the remarkable accompanying conditions upon which great trade and kindred movements depend for their immediate and

permanent growth. China, on the other hand, has nearly everything that tempts the exporter, manufacturer, promoter, financier, and engineer, which could be expected or desired in an extended expanse of new and undeveloped areas. Judged by certain standards, there could be great improvements of existing conditions in China, but were they already in operation, the field would be that much limited and not possess many of the novel and varied features which now make it so attractive. These manifold opportunities make China interesting and important to all who study her people and resources.

In the essential point of area, including that of all her dependencies, she is greater than the United States; in the more essential feature of population, which provides a great buying and selling force, she has four or five times as many inhabitants. It may surprise many of the readers of this article when I state in this connection that I believe, from careful study of the interior of China, that her population is greatly overestimated. I will not, however, enlarge upon this point, as I am saving it for specific and extended discussion. Sufficeth it to say that, even with considerable reduction in the present accepted figures, there are adequate millions in China to meet all the efforts of American and European achievement which will be devoted to them during the next two decades.

The field would not be so tempting were it small and the possibility of exploitation all known to the world after a few engineering and prospecting parties had traversed it in every direction. As it is, numerous individuals and groups of experts have repeatedly ventured into the interior—north, south, east and west—for the last quarter of a century, and yet our knowledge seems to be most limited. New plans are being framed every day for further study of the provinces and sections away from the treaty ports, and not a month passes that does not see a fresh expedition of engineers, prospectors, or government agents setting out from Hong Kong, Shanghai, or Peking. There is also a charm about the mystery of China's material wealth that fascinates the man who has in him any spirit of adventure, discovery, or of undertaking hazardous enterprises that may bring success or disappointment. There is a feature of gambling in this tendency to exploit China that appeals to the trust in good luck which all men possess in a degree. Enough, however, is known in positive terms to warrant what is being legitimately done.

POSSIBILITIES KNOWN AND UNKNOWN.

The invasion of China is not a wild chase into a desert, nor is it a search for the Garden of Eden. It is simply an eminently practical

movement based upon the best of reasons. Were China no larger than Siam or Corea, we would know now, with the amount of traveling and discovery that has gone on in the past, exactly what China has in store for foreign commerce, capital, and engineering skill. On the other hand, with China stretching away in all directions and covering over 4,000,000 square miles, these efforts have resulted in giving us merely a superficial and extremely limited idea of what there is in certain sections only. The larger part of China's possibilities remain yet to be stated in definite terms. What is known is ample evidence that the conclusions already drawn as to her latent wealth are logical, and they encourage without question far more extensive effort on the part of foreign interests. The world has been a long time in awakening to the opportunities of Cathay, but with the extraordinary appreciation which the events of the past year have aroused must come a proportionate determination upon the part of the nations most concerned not to allow the golden chance to be neglected.

In China's widest area, which extends 2,000 miles from south to north, or from Pakhoi to Kirin, and 2,000 miles from east to west, or from Shanghai to Batang and beyond, are found those immeasurable mineral and agricultural resources, partially developed or latent, which suggest mighty possibilities. There is that wonderful conformation of the earth's surface that permits of their successful development under modern conditions. Mountains and valleys, plateaux and lowlands, are found with that natural relationship which not only provides great river systems and means of inland transportation, but routes for artificial methods of conveyance and travel. Some of the deepest and longest streams of the world, with numerous tributaries, intersect China's richest areas. These in turn empty into, or are connected with, harbors which, in their frequency and excellence of location, provide the best ways of access to the outer world, and help to advance the interests of foreign commerce, both outgoing and incoming. The entire China coast line, winding in and out for nearly 2,500 miles, is dotted or indented with a marvelous succession of bays, inlets, and mouths of navigable rivers, that give her ideal facilities for coast and exterior commercial exchange by water transportation. Even after Great Britain, Russia, Germany, France, and little Portugal have had their pick of ports, there remain as many more, equally good, still in the hands of China—but coveted, I fear, by Austria, Italy, and Japan. Possibly the United States may be forced to look with longing eyes on some northern Chinese haven, if they shall wish to supplement their new territorial holdings in the south, and if they fail

to exercise the moral courage to keep China from her impending break-up. Should that possibility ever mature into a reality, let us trust that, to the honor and credit of the United States, the control of such a rendezvous for their ships of war and trade will only be secured by legitimate negotiation or treaty, and not by bulldozing tactics.

Now that America is a Pacific and Asiatic power with responsibilities equal, in some respects, to those of Great Britain, Japan, Russia, Germany, and France, she may find herself compelled to enlarge and protect her interests in many ways of which she now has no expectation, or of which she never dreamed in former years. May she have the mingled courage and judgment to get the best and avoid the worst in the conditions that confront her.

FOREIGN POLICY TOWARDS CHINA.

China is to-day the goal of a world movement. America and the great powers of Europe are all concerned in her industrial and political future as they are in that of no other land. But the present situation is so full of unrest as to be not only unsatisfactory, but threatening to the interests of those nations which supply the larger part of China's wants and provide a market for a considerable portion of her surplus products. Unless some mighty change is soon worked in the evolutions of politics at Peking, China will be divided. This is so evident that there is nothing gained by mincing words. The truth has been spoken often on this subject, but it cannot be repeated too frequently or too emphatically. Men, who like myself, have visited different parts of China, and especially the capital, are convinced that the only influence that can save this impending break-up is an understanding or combination on the part of the powers, which have more to lose than gain by this disaster, that they will use their united influences to prevent it. By references to understandings and combinations, I do not mean alliances sealed by treaties, protocols, or formal agreements, that might bring about unfortunate complications, but mutual purposes in policy, the achievement of similar ends, and the bringing of joint weight to bear where it would be invincible.

If this policy of exercising united influence would bring about war with Russia or any other prominent country with which the United States now has agreeable relations, it would not be popular; but such a contingency is out of the question. The strongest argument in its favor is the fact that it would prevent the possibility of war, or even talk of war. The united moral pressure of several leading powers will achieve the end without a suggestion of conflict, if it is once set in motion. Were the diplomatic agents at Peking of the United States,

England, Germany, and possibly Japan, once definitely informed by the foreign offices of Washington, London, Berlin, and Tokio, that they were to direct their efforts in unison to support the integrity of the Chinese Empire, maintain the open door and full freedom of trade according to the spirit and letter of the old Tien Tsin treaties throughout all China from Canton to Newchwang and from Shanghai to Chunking, the problem of China's future and of the interest of the nations named in China's development would be forever solved! With America, England, and Germany, supported by Japan, the countries which have the largest present and prospective trade in China, unitedly determined to prevent the division of the Empire and the infringement of the treaties by spheres of influence and discriminating duties, there would not only be an end to the quiet influences that are bending their energies to destroy the country's independence, but—what is of the greatest importance—there would be a broad, wide road opened for reform in China's central and interior government. The question of reform is always asserting itself in any discussion of China's future. China will never reform until the pressure from outside compels it. She has within her the elements of strength and virility yet remaining, if only they are brought into action, but they will never be utilized so long as foreign nations are weak and divided at Peking. On the other hand, let the principal powers show to China that they mean to protect their interests, not only by preserving the integrity of the Empire, but by compelling her to institute new conditions in the administration of law, justice, finance, and other important conditions of government, and they will witness the evolution of the new China and the passing of the old.

With this review of the politico-industrial situation I must rest for the present, reserving for a succeeding issue of THE ENGINEERING MAGAZINE the more detailed consideration of those material possibilities of the country especially interesting to the Magazine's constituency.

ECONOMY IN THE USE OF SUPERHEATED STEAM.

By R. S. Hale.

SUPERHEATED steam was thoroughly tried and tested about forty years ago both in America and in Europe, and, although it came into fairly frequent use, was finally discarded, in spite of the acknowledged economy, on account of practical difficulties. Of late it has been revived in Germany and France, with modifications that appear to have made it a practical success, and as its use will probably spread to England and America, the time seems opportune for a statement of the principles on which the economy due to the use of superheated steam depends, and for suggestions as to what type of steam plants may possibly profit from its use. In brief, we may say that for plants that are simply arranged—*i. e.*, with only a few engines, a few boilers, and a fairly simple system of steam piping—that are large enough to require a reasonably capable engineer in charge, and that run regularly, superheated steam, intelligently applied, appears to offer the opportunity for a considerable saving in coal.

1. The superheated steam may be produced in three ways, of which the first is to place the superheater in the flue where the gases will strike it after they leave the boiler. This will of necessity result in a small gain in boiler efficiency, since the heat put into the steam would otherwise be wasted. The amount of heat thus gained would not be over two or three per cent. in a boiler worked at ordinary rating, and the position of the superheater in the flue makes the amount of superheat very variable; for, if the boiler is worked easily, the temperature of the gases is only slightly above the temperature of saturated steam, whereas, when the boiler is forced, the difference of temperature between the gases and the steam increases much faster than the amount of steam to be superheated, so that the amount of superheat gained is very much greater.

While the installation of a superheater in the flue certainly saves a few per cent. of heat, it should be remembered that an economizer for heating the feed water would save more heat at less expense. With a superheater, the difference in temperature between the gases and the steam is only about 200 degrees; with an economizer, the difference in temperature between the gases and the water would be about 400 de-

grees, and the resistance of the surface to heat transmission would be very much less; so that it is safe to say that a given area of economizer heating-surface would increase the boiler efficiency five times as much as the same area of super-heating surface, besides costing less to install, and less to keep in repair.

2. The superheater can also be installed in a separate furnace. In this case, of course, additional coal is burned, but additional heat is put into the steam, and it is theoretically possible to make a superheating furnace that will be as efficient as a boiler, in which case there will be no loss in the total boiler efficiency. There are, however, practical difficulties in the way of an efficient furnace for separate superheating, of which one is that the superheating furnace would be of small size compared with that of the boiler, and it is safe to say that, if a separate furnace is used for superheating, the total efficiency of production of the steam will be diminished.

3. The superheater may be placed in the path of the gases after they have passed over a portion of the heating-surface, but before they leave it finally. For instance, in a Babcock & Wilcox boiler a superheater may be placed between the tubes and the drum, beween the first and second passes of the gases. In such a case the effect on the economy of the boiler is not immediately apparent. The gases, of course, give up the same amount of heat to the first portion of the heating-surface as they would if there were no superheater present; they then give up a portion of their heat to the superheater. The heat given to the superheater goes to increase the total efficiency, but the giving up of this heat diminishes the temperature of the gases, so that the amount of heat given up by them to the remaining heating-surface is less than it would have been without a superheater. Careful analysis, of which it is unnecessary to give the details, shows that the net result is the same as that due to an increase of heating surface. For example, suppose a superheater of 500 sq. ft. heating-surface is added to a boiler, and suppose also that the superheating-surface offers twice as much resistance to transmission of heat as water-heating-surface does; then the gain in efficiency would be exactly the same as if 250-sq. ft. of water-heating-surface had been added to the boiler. The percentage gain in efficiency on any particular day or test would vary as the boiler was forced or worked easily, and also as the air supply varied, but in every case there would be a slight gain. The gain in boiler efficiency for a superheater thus placed would be greater than that resulting when a superheater of equal area was installed in the flue, since, with the superheater in the flue, the gases could not be

reduced below the actual temperature of the superheated steam, while, with the superheater between the first and second passes of the gases, the gases, as they pass over the final portion of the water-heating-surface, would be reduced to a lower temperature. In addition, this position of the superheater makes the degree of superheat more uniform, and the superheater may be much smaller than if it were placed in the flue. Theoretically the best place for the superheater would be directly above the furnace, but this position is impracticable on account of the intense heat.

It should be noted, however, that an increase of boiler heating-surface in comparison to the work done will in every case increase the boiler efficiency to as great extent as a superheater will, and an economizer will increase the boiler efficiency more than a superheater will, while the expense of installation and maintainance of either boiler heating-surface or economizer heating-surface is at present much less than the expense of installation and maintainance of the same effective area of superheating-surface.

We come now to the second division of the subject, the losses in the steam pipes in the transmission from the boiler to the engine. These losses consist of radiation, fall of pressure, and leaks, and in the case of radiation the loss is increased in direct proportion to the amount of superheat. This is the case even when the steam is so superheated that there is no condensation in the pipes, since, if the steam starts dry at the boiler and loses heat by condensation, the actual loss is nevertheless smaller than if the steam starts superheated, and loses a part of its superheat as it passes to the engine, the heat lost being in proportion to the temperature of the pipes, whatever the condition of the steam inside.

The second loss in the steam pipes is due to fall in pressure, which depends on the velocity of steam; and, since superheated steam takes up greater volume and hence moves with greater velocity than saturated steam, the fall in pressure will be greater in pipe of the same size, while, if larger steam pipes must be provided, greater radiation losses will occur. This is true whatever size of pipes be used; but it seems to me that a great majority of plants use too large pipes. The steam pipes close to the engine must be large, otherwise the pressure falls during admission to the cylinder: but, if a large steam pipe or steam reservoir be provided close to the engine, of sufficient size to keep up the pressure during the admission period, then (for an engine cutting off at one-quarter stroke) the steam pipe from the boiler to this reservoir need be of only one-quarter of the area or one-half the

diameter usually used. The writer has often seen a 12-inch main with 6-inch offset pipes, leading to the engines, and wondered whether a 6-inch main with 12-inch offsets to the engines would not give a higher initial pressure on the indicator card. Still, whatever size of pipe or arrangement of sizes be used, the fall of pressure and consequent loss would be greater for superheated steam than for saturated steam of equal weight.

The third loss from steam pipes is from leaks, and most engineers, even those who make carefully the ordinary tests of their plants, will be surprised to find out how much steam actually leaks away, even if the joints appear staunch and tight. The following figures show the results of tests of plants.

Leakage in per cent. of useful steam, assuming plant to be worked steadily to its full capacity:

Mill	5	per cent.
Mill	16	per cent.
Electric Plant	7	per cent.
Electric Plant	2½	per cent.
Steamship	1½	per cent.
Steamship	6	per cent.
Steamship	10	per cent.
Waterworks	2½	per cent.

If the plant is kept under steam but worked only one-half its capacity, the percentage of the useful steam lost in leaks would be doubled. If the plant is worked one-third its capacity the percentage would be tripled, and so on. Thus the electric plant No. 3 in the above table, working at an average of one-third its capacity, lost 21 per cent. of the steam actually used.

I know of no leakage experiments similar to these made in plants using superheated steam, and can therefore do no more than estimate the probable results. If the temperature of superheat remains uniform, the leakage need not be much greater than the leakage with saturated steam; but with saturated steam the variations in temperature of the pipes are only slight, except when steam is shut off, whereas with superheated steam not only is the total change in temperature when steam is shut off very much greater, but the temperature of superheat and the temperature of the pipes is changing every hour and every minute, and often to a considerable degree. Now, since the leaks in the steam pipe lines are due generally to expansion and contraction caused by changes in temperature, it is safe to estimate that the leaks in a line of steam pipes carrying superheated steam, which has greater

changes in temperature, will be considerably greater than those from a similar line carrying saturated steam, both lines being looked after with equal care.

Finally, we come to the engine; and here we find a clean net saving which, in the case of a high degree of superheat, may amount to from 10 to 20 per cent. The difficulties at the engine are only the question of lubrication, which seems to be satisfactorily solved by the liberal use of some of the heavier mineral oils. There is, of course, considerable difference between different engines, depending largely on the valves. Vertical engines with poppet valves will give least trouble, while horizontal engines with unbalanced slide-valves will require the greatest care. Recapitulating, we find for superheated steam:

1st, a slight gain at the boiler, although a less gain than that can be obtained by increasing the boiler heating-surface, or by the use of an economizer.

2d. An increased loss in the steam pipes, due to the increased radiation, fall of pressure, and increased leaks.

3rd. A large gain in economy at the engine.

It is obvious that the sum total of these results will be very different in different plants, and even in the same plant may vary according to the way superheat is produced, and its amount.

In regard to the kind of superheater, the analysis above given has shown that the use of a superheater beween the first and second passes of the gases gives a little greater economy than either of the other methods suggested as an alternative. This method also permits the use of a very much smaller superheater than is required when the superheater is placed in the flue, and gives a much steadier and greater amount of superheat; it is this type of superheater that has come to the front in Germany and France as a practical form. Since the smaller area of superheating surface here required diminishes the first cost, and also the cost of maintainance, we find that both theoretical and practical considerations indicate that, if a superheater be used at all, it should be placed in this position. A still further advantage for this position is that it leaves place for an economizer in the flue, while with a superheater in the flue there might be no room for an economizer. The superheater in a separate furnace gives less power economy, and costs more, but may possibly be useful in one particular case which is as follows: If the distance between the boiler and engine is very large, then if superheat is produced at the boiler, it will have almost or entirely disappeared at the engine, and there will be little or no economy. If, however, a superheater is placed in a separate fur-

nace, close to the engine, then the full saving due to superheat may be realized and this advantage may more than offset the cost of the separate superheater and furnace.

In regard to the degree of superheat, it is obvious that if superheaters are used the full advantage should be taken. The cost of installation and cost of maintainance of a superheater are only slightly greater if a high degree of heat is obtained than if the steam is superheated only slightly, while the saving in coal increases to a very great extent. The indications are clear, therefore, that as high a temperature as practicable should be used. And it should be noted that the modifications over ancient practice which appear to have made superheat a practical success abroad are placing the superheater between the first and second passes of the gases and the use of a very high degree of superheat. Now, with a superheater placed between the first and second passes of the gases, giving, say, 500 to 700 degrees F. temperature of the steam, with a small amount of piping, with the plant worked all the time, we have:

Gain at boiler	2	per cent.
Gain at engine	10 to 20	per cent.
Extra loss in pipes, radiation, say	1	per cent.
Extra loss in pipes leaks, say	3	per cent.
Extra loss in fall of pressure, say	½	per cent.
Net gain	7½ to 17½	per cent.

Such a gain in annual coal bill would probably be enough to pay for fixed charges and maintenance of superheater. On the other hand, suppose there is double the amount of piping, and that the plant averages only one-third as much net work; we then have:

Gain at boiler	2	per cent.
Gain at engine	10 to 20	per cent.
*Extra loss, radiation	6	per cent.
*Extra loss, leaks	18	per cent.
Extra loss, fall of pressure	½	per cent.

Net loss 2½ to 12½; of course, superheating will not pay.

It should be noted that if it pays to equip part of the boilers of a plant with superheaters, it will pay better to equip them all. If only a part of the steam is superheated, then some of the superheat serves only to dry out the moisture in the rest of the steam and has no effect at the engine, whereas, if all the boilers have superheaters, all the superheat is effective in improving the economy and none is wasted.

* Double the loss divided by one-third as much work done, making percentage six times as great.

THE DEVELOPMENT OF GERMAN SHIP-BUILDING.

By Rudolph Haack.

II. THE SHIP-YARDS ON THE NORTH-SEA COAST.

BELL-BUOY.
Aktien-Gesellschaft Weser.

IN reading the short review of the history of evolution of German ship-building, which formed the initial paper of this series in the July issue of THE ENGINEERING MAGAZINE, the question must arise: How could development so remarkable be attained in a time relatively so short? England and France had begun much earlier to build iron-clads and torpedo-boats, and the experience of the English engineers in designing and building fast and elegant transatlantic passenger steamers was much older and fuller than that of their German rivals.

To give a general answer to this question is the principal object of this second article, and, first of all, it must be cordially admitted that the British ship-building has served from first to last as a splendid model, which the Germans have not hesitated to use on the greatest scale. Many German naval and mechanical engineers

CHINESE PROTECTED CRUISERS HAI YUNG, HAI SHEW AND HAI SHEN.
Length, 315 ft.; beam, 41 ft.; depth, 24 ft. 7 in. Mean draught, 16 ft. I. H. P. 8,400 at a speed of 20.75 knots and displacement of 2,950 tons. Built at Stettin, 1897-98.

held positions in the largest British yards, thus adding to their knowledge; others made frequent trips across the channel to study the equipment and organisation of British workshops. Much of the heavy handling-machinery and many of the machine tools were bought in Britain. It is a pleasant duty to admit that, without Britain as a teacher, no such rapid success could have been attained.

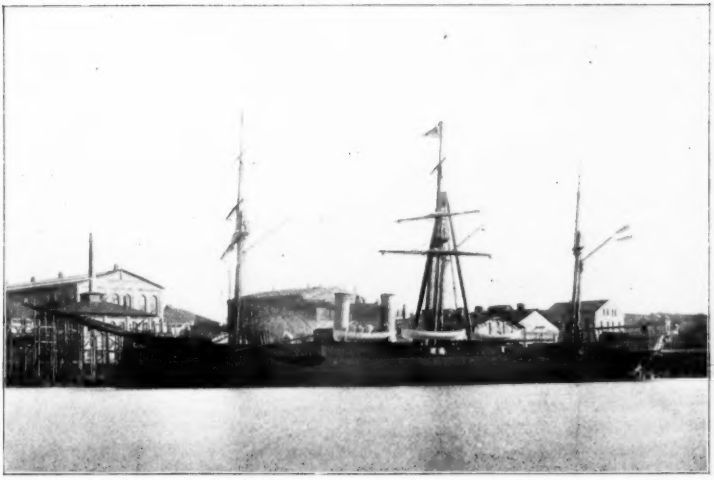
The already mentioned ship-building institution near to Stettin was very early merged in the Gewerbe Institut of Berlin, and at the latter place the number of lectures and their intrinsic value greatly increased. A second forward step was made when this institute was developed into the existing Technical High School at Charlottenburg, in which the students who are enrolled in the division for ship- and marine-engine building are to be counted by hundreds.

Young men with preparatory technical training go from this school into practical work, and if, as is the case with many of them, they have any desire to acquire that practical knowledge not obtainable at a school, they are very soon fitted to fill the highest and directing positions in large ship-yards, to the profit not only of the works employing them, but also to their own profit and to that of the national industry of ship-building.

Theoretical training is to be had also in the many special technical schools, and in these are trained those who do not aspire to the highest positions in the largest machine shops and ship-yards. The many training schools founded in the shops and yards, by the school boards of many cities, have a great and good influence on clubs, workmen, and apprentices, and thus better, cheaper and faster work is secured.

It is not so easy to determine quickly the exact share that the different yards have had in the general development of the whole. They have done much to develop practically engineers, constructors, designers, foremen, and workmen; they have organised and built up yards and machine shops; they have utilised existing facilities and materials, and an opinion can only be reached by a short description of the ship-building yards, their origin and their present capacity; in this manner the differences between them, as well as the common striving of them all for one great national perfection, can be recognised.

Mention has already been made of the three great yards of the Imperial navy, of which the oldest at Danzig has remained the smallest, because the city has been given up as a war harbour since the selection of Kiel, much better situated with reference to the whole



CHINESE PROTECTED CRUISER NAN THIN, BUILT AT HOWALDTSWERKE, KIEL.

Length, 253 ft.; beam, 36 ft; draught, 18 ft. Displacement, 2,200 tons. Indicated horse-power 2,400, at a speed of 14.2 knots.

Baltic. Therefore the yards at Danzig were devoted principally to the building and repair of new cruisers and small vessels, especially as there were no facilities whatever for the shaping and handling of heavy armour.

The naval works at Kiel and Wilhelmshafen consists of great harbours for the iron-clad fleets of the Baltic and North Sea, and in these extensive dockyards there are stores of munitions and weapons and other war materials, as well as a great number of ships and machine shops for new work and repairs of men-of-war of every kind.

A special description of the organisation and arrangement of these works is not permissible; but it can be said that they are technically directed, in charge of and under the management of naval and mechanical engineers who are graduates of the high school at Charlottenburg, who further perfected their knowledge in the Government yards, and in other German and foreign yards.

To recruit skilled labourers in large numbers was at first a problem of extreme difficulty—especially at Wilhelmshafen, an entirely new place. They had to be coaxed there from other ship-building cities by all sorts of premiums and inducements in the way of dwellings, supplies, wages, etc. Now there is a large force of workmen on hand,

quite sufficient for usual requirements, but easily capable of increase in numbers in special cases.

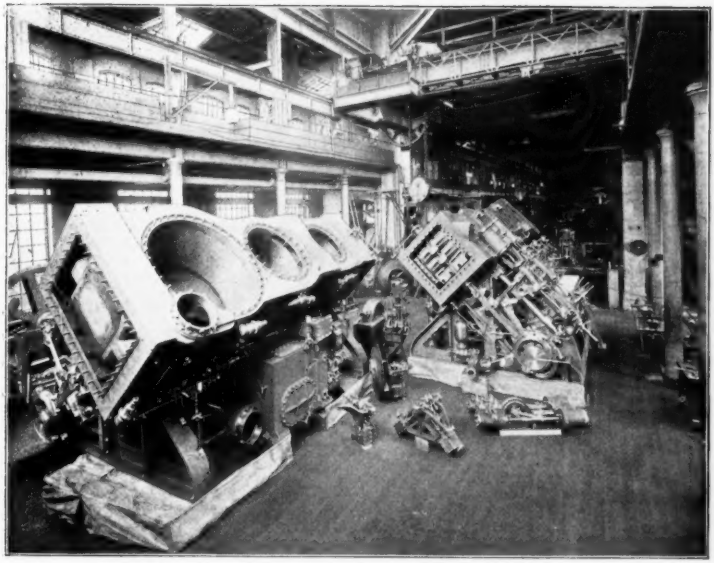
The products of these three great yards in men-of-war of all kinds, built from plans and specifications furnished by the Imperial Admiralty Bureau of Naval Construction in Berlin, are equal to the best in any foreign land, and in performance they have in recent years shown constant betterment.

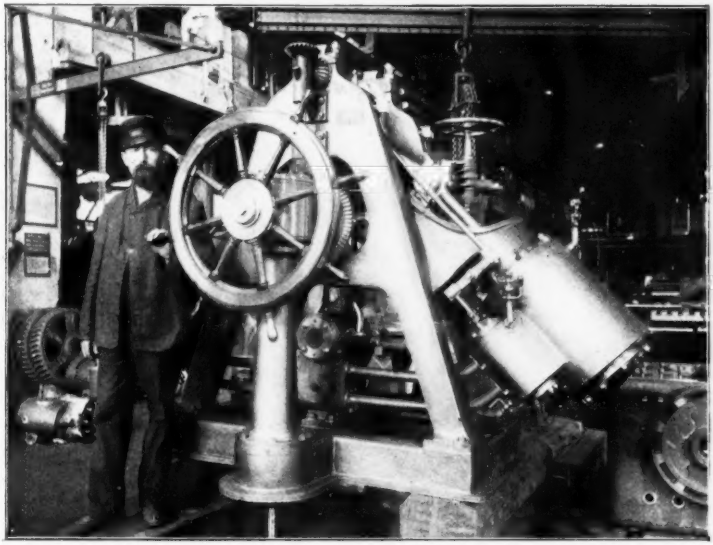
Private yards, busy for the most part with merchant steamers, but also with war vessels for the German navy, have recently increased very greatly both in number and size. For sea-going vessels there are not less than forty-nine yards, of which thirty are on the coast of the North Sea and nineteen on the shores of the Baltic. In addition there are seven yards on the Rhine and in Westphalia, and three on the Elbe, which build boats principally for river and canal traffic, but also undertake to deliver smaller vessels, suitable for coast trade.

Beginning at the western boundary of Germany, the first yard is that of Jos. L. Meyer, in Papenburg, founded in 1872 by its present owner. It began on iron ships, and soon added those of steel up to 1,000 tons displacement with the necessary engines. It also builds smaller vessels for sea and river traffic. The capacity of the yard is about 1,350 to 1,750 tons annually, with engines from 306 to 1,570 i. h. p.; the yearly turnover is about 700,000 mk. In addition to shipbuilding it also constructs dredges and hopper-barges. The largest steam engine is 400 i. h. p. The yard covers an area of nearly 7½ acres. It employs an engineering staff of twenty-three to design and construct the vessels, the manager being Mr. Jos. L. Meyer himself. The number of workmen last year was four hundred.

This yard, although one of the smallest, has steadily grown and done work so excellent that the Imperial navy prefers to honour it with orders for smaller vessels and craft, and in addition the Imperial Government has already ordered several steamers, now finished, for the African colonies..

After this come, in the order mentioned, four yards in Emden, Spiekerhörn, West-Rhauderfehn, and Oldenburg, which thus far have not attained great importance; but the next one, the Aktien-Gesellschaft "Weser" in Bremen, has long been of great importance. It was founded by Carsten Waltjen as early as 1844, and at first limited its work to castings, steam-engines and a few wooden river steamers. The present company took over the business from the founder in 1872, and since then it has been busy with war vessels, as well as passenger and freight steamers for ocean and inland waters In the work year





MARINE ENGINES AND STEAM STEERING ENGINES. AKTIEN-GESELLSCHAFT WESER, BREMEN.

1897-1898 about 9,800 gross tons with 11,500 i. h. p., were delivered with a turnover for the plant of 4,000,000 mk. The staff, now directed by Messrs. Gleim, Graf, Zeltz, and Unger, having charge of construction as well as management, consists of sixteen naval constructors, thirty-two mechanical engineers, and eighty-nine foremen and employees. The workmen numbered 685 in 1872-1873, but have increased to 1,772 for the last year. The principal yard is on the Weser, with a repair shop and dock at the free port, and the whole plant covers an area of nearly 9 acres.

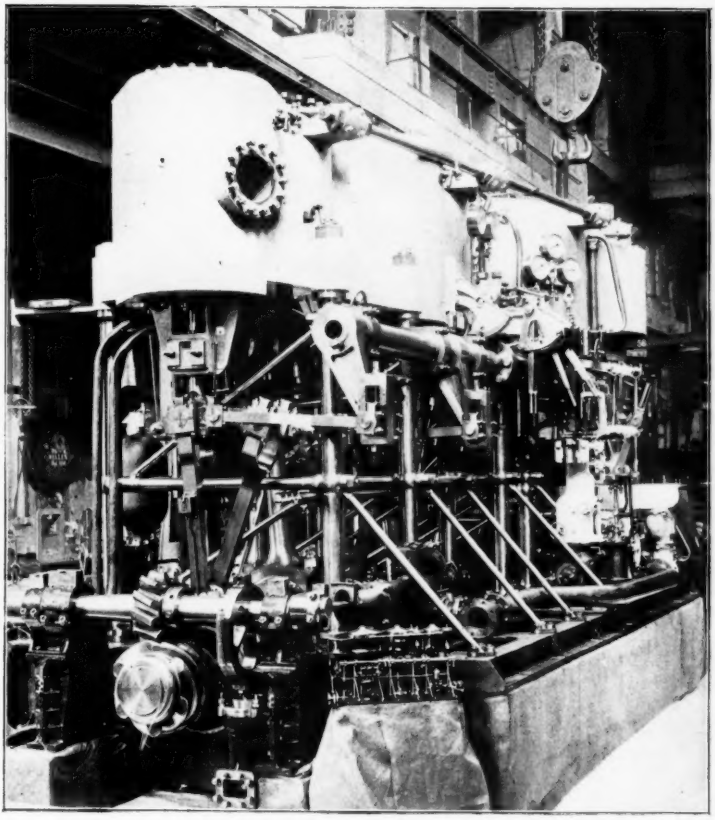
In addition to vessels of all kinds the "Weser" makes dredges, cranes, hoisting appliances, and stationary steam-engines, while the foundry supplies large castings of iron and bronze.

As already mentioned, these yards have built a number of war-ships for the German navy and for foreign powers, and thus gained great experience in this field as well as in the building of merchant ships. Its products are rated among the best in the whole of German ship-building.

From the combination of several old yards for wooden ships there was formed near Bremen the "Bremer Vulkan" Schiffbau und Maschinenfabrik-Vegesack, a plant that in the short time since its organisation has been uncommonly active and has made noteworthy progress. Its yards cover about 5 acres, and there is place for ten ships on the ways at once.

The building of steam and sailing ships for high-sea fishing was

STEAM DREDGE BUILT BY THE AKTIEN-GESELLSCHAFT WESER.

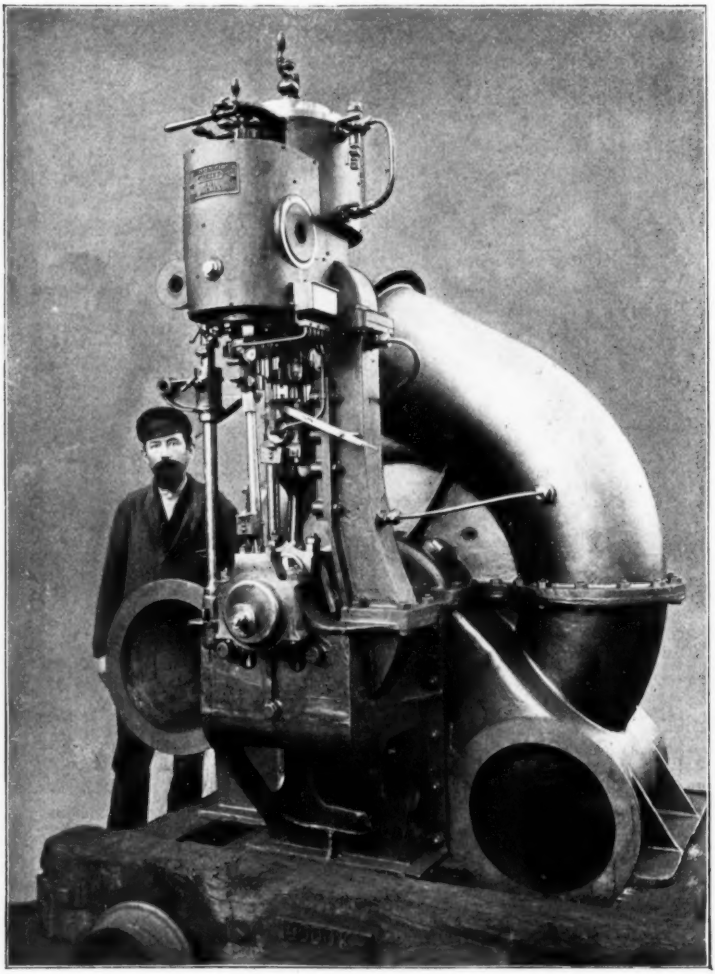


BATTLE-SHIP ENGINES CONSTRUCTED AT THE AKTIEN-GESELLSCHAFT WESER, BREMEN.

at first the principal occupation, and yielded good profits, but very recently they have begun building large freighters and oil tankers. At the beginning of this year two steamers, each of 5,000 tons gross, for the North German Lloyd, and eleven other large and small ships were on the ways. For all of these, including five just delivered, the gross registry was 21,686 tons.

Since organisation under the present management the Bremen "Vulcan" has earned good profits. It declared dividends of 10 per cent. to its shareholders in each of the years 1896 and 1897.

Further down the Weser, in Hammelwarden, is a little yard build-



A STEAM CENTRIFUGAL PUMP.

ing wooden and iron ships of small size; in Brake there is a second yard of the same kind; then comes in Geestemünde the important plant of the Joh. C. Tecklenborg Aktien-Gesellschaft, founded by Joh. C. Tecklenborg in 1840 in Bremerhaven. He built wooden sailing vessels

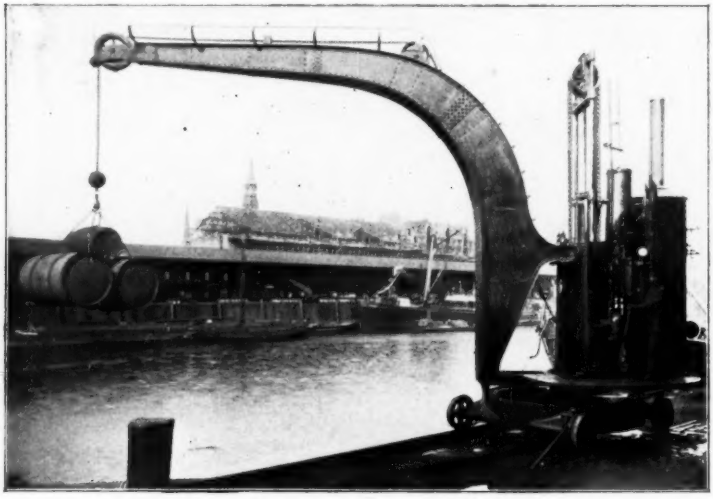
in the yard up to 1879, and then iron sailing vessels and steamers, the engines being ordered elsewhere; but in 1891 the new company began building its own engines in its new machine shops. They are thus wholly independent, and can deliver large freighters or sailing vessels, of which one, the largest in the world, the "Potosi," bark rigged with five masts, deserves special mention. This vessel is 365 ft. long, 49.6 ft. beam, and 31.3 ft. hold; it measures 3,854 net tons, and was built in 1895 for the house of F. Laeisz, of Hamburg.

Ship yard, machine shop, dry-dock and marine railway cover an area of 18 acres, and are so skillfully situated on the Geeste, a small

FLOATING SHEARS OF 85-TONS CAPACITY.
Built by the Aktien-Gesellschaft Weser, Bremen, 1887.

tributary of the Weser, that the building and launching of ships of the above dimensions is possible. Thus far no war vessels have been built here, but a number of merchant vessels, both sail and steam; and activity has so much increased that against 4,340 gross tons delivered in 1890, in 1898 not less than 10,105 gross tons complete, with engines of 5,100 i. h. p., were finished, the cash turnover being, at the end of that year, close to 2,500,000 mk.

The general manager is Mr. George W. Claussen, who has under him a staff of eleven naval constructors and fourteen mechanical engineers, besides forty-seven other foremen and clerks. Last year nine hundred and eighty-one labourers were employed as against eight hundred and fifty-five in 1890. There were foreign orders at these yards for two sailing vessels and ten steamers, a total of 10,800 gross tons and 5,500 i. h. p. Besides ships the company builds oil tanks, sluice-gates, feed-water filters, patent ribbed tubes for boilers, etc. The well merited reputation earned by this yard has been built up largely by the splendid design and careful execution



WHARF CRANE, BUILT IN A BREMEN SHIP-YARD.

of the ships ordered, and it now occupies a leading place among German ship-building yards.

Immediately adjoining the above yard and also on the Geeste lies the yard of G. Seebeck, Aktien-Gesellschaft, whose rise has been very

rapid; it is well deserving of recognition. Last year it delivered nine ships of a total of 4,000 net tons, one of these being of 1,988 tons for the North German Lloyd. The ships delivered and on the ways in the early part of 1899 measured a total of 9,709 gross tons. This firm

TRANSPORTING THE WESER LIGHT HOUSE TO ITS POSITION.
The tower is being floated to its place between two pontoons.

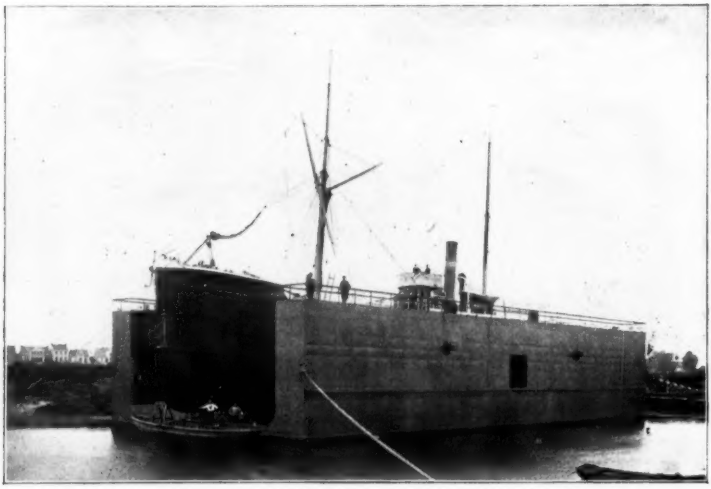
not only builds new ships, but has also an extensive repair business, a profitable branch, and they make use of a dry dock dating from an earlier period.

There is yet another yard at Geestemünde on the Geeste, that of the Rickmers-Reismühlen, Rhederei und Schiffbau Aktien-Gesellschaft, which builds freighters, both sail and steam, for the rice trade of the firm, and also fills orders for others. The vessels delivered and still on the ways at the end of 1898 measured a total of 9,506 gross tons. This yard is not a new one, and was formerly very active on wooden ships, but recently there has been marked increase in vessels of iron and steel.

The yard of F. W. Wencke in Bremerhaven is principally busy

with small vessels. Last year, to January, 1899, five steamers were on the ways, with a total of 650 gross tons. The principal business is, however, repairs and for this purpose the yard uses a large dry dock.

Turning now to the Elbe, we reach Hamburg, the most important sea-port in Germany, whose commerce and trade have in recent years so increased that the city rivals the largest in the world. In the old days of wooden ship-building there was great activity in Hamburg yards, but all this has died out and, since iron has supplanted wood, is limited to repairs. Only one large yard, the Reiherstieg-Schiffswerfte, founded in 1863 by the president of the Hamburg-American Packet Company, Mr. Godeffroy, undertook to build iron ships on the

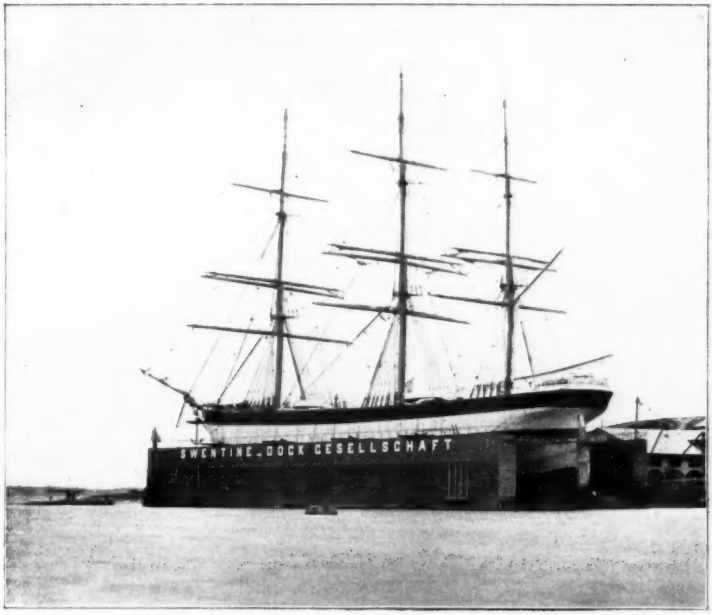


FLOATING DOCK OF THE AKTIEN-GESELLSCHAFT WESER. BREMEN, 1886.

Elbe, and this without very great success. In those days all big orders were captured in England, and only in 1873 did the Reiherstieg build the first two steamers for the company, each of 938 gross tons, an order considered important in those days compared to the little orders for harbour boats which had thus far been given. A better business was done in repairs, which were constantly increasing and yielding good profits, and these assured the continued life of the yard.

Early in the eighties this yard was taken over by a joint-stock company and the increase of working capital obtained at that time permitted great improvements in, and addition to, the work shops and

their equipment. In this way it was possible for this yard to undertake the construction of the already mentioned Rhätia, and to secure, among other equipments, a big floating dock. The latter permitted repairs of larger vessels, and orders for new construction increased in both number and size, one freighter built here having a registry of 8,500 tons; the cruiser Marie, for the Imperial German navy, was also built in this yard. It ranks as the first in time in the regeneration of modern flourishing German ship-building.



FULL-RIGGED NORWEGIAN SHIP WINNIPEG.
Vessel of 1 303 gross tons in the Swentine dock at Kiel, 1890.

It is only in a large commercial city like Hamburg that a yard like that of Blohm and Voss, Kommanditgesellschaft a/Aktien, could attain in so short a time the prosperity it now enjoys. The men whose names appear in the firm title are founders, part owners, and managers. Provided with abundant means, they established in 1877 in Steinwärder, on the left bank of the Elbe, a yard splendidly equipped from the very start, to build ships and engines, from that time to this they have aimed to surpass all other German yards in both size

and capacity. At first they were busy with orders from merchant vessels and with repairs, and for the latter purpose secured several floating docks, one of 17,500 tons capacity. More recently Blohm and Voss received orders to lengthen three large mail steamers of the North German Lloyd, and this was rapidly and satisfactorily done. Seventy feet were added to the length while the steamers were in the big floating dock, a totally new experiment in ship-building practice. The Imperial navy had already given this firm several small orders, but recently honoured them with the contract for one of the largest armoured battle-ships; for the merchant service this firm built the well and favourably known freighters Pennsylvania and Pretoria, each of 12,800 gross tons register, with engines of 5,000 i. h. p. These two steamers are among the largest in the world.

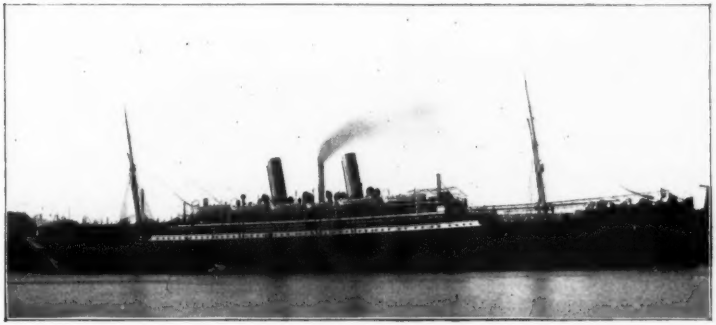
In this great establishment one sees the manifold advantages to be obtained from a systematic plan of workshops and ways. Everything was ordered and built in accord with the original plan, every new experience utilised, so that the whole, completed in harmonious perfection, permits rapid, thorough, and very profitable work. In addition, there is never any lack of work in Hamburg under normal conditions; there are also auxilliary supply depots and trades in great number Wages are indeed very high, but this leads to installation and steady improvement of automatic machinery, etc., and thus the disadvantage of high wages is equalised.

A neighbouring but smaller yard is the Schiffswerft und Maschinenfabrik (formerly Jansen & Schmilinsky) Aktien-Gesellschaft, busy chiefly with orders for small vessels. Founded by Jansen & Schmilinsky, it was taken over by a joint-stock company in 1888 and is to-day managed by Mr. Thulesius. The area of the yard is a little less than 2½ acres, and its chief business is the building of small passenger, freight, and tug boats, and lighters, and the repairing of vessels and engines. The greatest length of vessel finished by this firm is 158 feet. and the largest engine built about 400 i. h. p. During the last ten years a gross annual tonnage of 555 to 750 was turned out and the engine powers ran from 1,600 to 1,750 i. h. p. The yearly turnover reached in 1897 700,000 mk., of which five-sevenths was new work and two-sevenths repairs. The work was done under the management of seventeen engineers, foremen, and officers, and three hundred and fifty workmen. On foreign orders this little yard has already supplied one hundred and twenty-three vessels of a total of 5,000 gross tons and 6,570 i. h. p. Among these orders were several for the German colonies in East and West Africa. The firm has a

high reputation for this kind of boat and constantly secures new orders.

Another yard, B. Wencke Sons, was started by Mr. B. Wencke in 1847, and in 1858 James Empson & Co., who added a machine shop, joined the firm. Until 1876 only wooden ships were built, but since that time small cargo boats, fishing steamers, tug boats, etc., have been constructed. The output rose from 30 tons with 75 i. h. p. in 1890 to 240 tons with 570 i. h. p. last year. Two engineers and eleven foremen and officials have positions in office and workshops, in which such other work as steam boilers, tanks, and pontoons is also undertaken. The firm is mainly occupied with numerous repair orders, and is well equipped with a dry-dock, a marine railway, and several slips. The area of the yards is a little less than 5½ acres.

In the smaller Hamburg yards the building of new ships is generally a secondary consideration and merely serves to give employment to a pay roll of efficient workmen, who at all times must be ready for the rapid and also very profitable repair work. This is especially true of the yards of Heinrich Brandenburg, equipped chiefly for repair orders, founded in 1843 at Steinwärder and occupied until 1873 with building wooden vessels. For modern repairs, with which it is mostly busy, this firm has a large floating dock of 3,600 tons lift, a marine railway, etc. The management and pay roll comprises three naval constructors, five mechanical engineers, twenty-two foremen and office force, and the number of workmen rose from three hundred in 1890 to eight hundred in 1897. New orders are for small steamers only. The area of the yard is about 3 acres.



NORTH GERMAN LLOYD TWIN-SCREW STEAMER FRIEDRICH DER GROSSE.

Length, 525 ft.; beam, 60 ft.; depth, 38 ft. Displacement, 10,536 tons. Speed, 16 knots 7,500 indicated horse-power. Built by the Vulcan Works, 1896-97.

There are also other small yards, that of Wichorst and that of H. C. Stülken Son, the former building twenty-nine steamers, tug boats, and lighters, a total tonnage of 4,590 gross, and the latter twenty-two small vessels and boats, a total of about 589 gross tons. Also near Hamburg, in Harburg, the firm of Holtz, founded many years ago, builds steam pleasure-launches and other small steamers both for home and abroad. The yards with machine shop cover about 4½ acres and give employment to four hundred workmen, who build the little boats and everything appertaining to them.

On the shores of the Elbe, at Hamburg, and below toward the sea, as well as on the west coast of Holstein, there are a number of little yards busy on small steamers and sailing vessels, but a mention of their names must be sufficient. In Neuhof on the Reiherstieg, the yard of G. Wolkau, in Cranz that of I. Sietas, in Glückstadt that of J. & H. Gehlsen, in Wewelsfleth those of J. Junge and J. Peters as well as that of I. C. Wriede in Finckenwärder, in Tönning that of Schömer & Jensen, which in 1898 built eight little vessels with a total of 1,132 gross tons register, and finally the yard of Johs. Thormälen & Co., in Elmshorn.

All these little yards merit mention for their help in the great national work of German ship-building, as they add to experience, train workmen, and also because they are themselves growing in importance.

SYSTEMS FOR THE REMUNERATION OF LABOR.

By P. J. Darlington.

IN the June number of THE ENGINEERING MAGAZINE I presented a general discussion and comparison of plans for remuneration of labor. The conclusions were unfavorable to the premium plan, and Mr. F. A. Halsey replied in the *American Machinist* of June 22nd in its defence.

A careful study of this reply does not discover any defects in my previous treatment, which it is now proposed to confirm and illustrate more fully in answer to Mr. Halsey's objections. Mr. Halsey claims that piece work is wrong in theory and a failure in practice; that he has discovered a good system in a combination of piece pay and time pay, which he calls the "premium plan." He urges manufacturers to throw out piece work and substitute this system.

I contend that the claims of the premium plan are founded on false assumptions; that piece pay alone is more direct and effective under all conditions; that piece work is suited to its purpose, and has failed only when misapplied through ignorance of its principles; and that the premium plan cannot accomplish the best purposes of piece work.

In making a detailed study of plans for remunerating labor, we must get a clear idea of their purposes and means available, define the terms to be used in the discussion, review the characteristics of each plan, and, finally compare their effects on manufacturing economy.

In general the cost per piece of product is made up of two elements:

1st.—Product expenditures, consisting of the wages paid to the operator per piece produced ("wages cost"), and the material actually entering into the product, together with that maintainance and operation which is dependent on the number of pieces produced, as, for example, additional power to drive an increased cut, renewal of dies for drop forgings, royalty on designs.

2nd.—Plant expenditures, or those charges which must be made against each piece of product to cover interest, taxes, insurance, depreciation and maintainance of property, and those fixed general operating costs which are annual expenditures and independent of the productiveness of the plant. We will call this cost per piece "equipment cost."

The purpose of all plans for remuneration of labor is to reduce the total of these two piece costs and maintain the smoothest possible operation of the works and highest quality of product.

Two pay elements are available for remunerating labor:

1st.—Time pay, based upon a day rate or arbitrary time value assigned to each worker regardless of the product of his labor.

2nd.—Piece pay, based upon the amount and quality of product regardless of the individual worker and expressed in a piece price. This piece price may be either fixed or dependent on the speed of production; it may be increased or decreased (by a "change factor") when the speed of production has reached a fixed point ("change limit"). This change of price may affect all of the pieces on the contract, or only those turned out after passing the change limit.

This gives a number of sub-divisions of piece pay, several of which have been used in manufacturing works. "Piece work" is piece pay in which the piece price is fixed and independent of the speed of production. "Reduced piece work" is the result of reducing the piece price (on additional pieces only) when the speed of production reaches a change limit.

In the "Taylor differential piece-rate" system, the piece price is at first very low, but when the speed of production has reached a high predetermined change limit, the piece price is raised on all pieces in the contract, provided that the workmanship is strictly first-class. If, however, the workmanship is inferior but passable, the piece price remains at the very low value. This results in a higher average pay per piece, the faster a worker produces and the better the quality of his product.

The "premium plan" combines two elements:

1st.—"Liberal" time pay to a low limit of speed of production (full day pay for less than a day's work), with the promise that this low limit shall be set from actual shop results and records.

2nd.—Reduced piece work, or less than proportional piece price on the additional pieces only.

In this system the faster a worker produces the lower his average pay per piece.

Piece work pays for the acceptable product only, thus enforcing wage penalty for failure in amount or acceptability. Day work pays for the time that can be spent on the work. The Taylor differential piece-rate system pays for the acceptable product, with a special reward for quick and perfect work, and a special wage penalty for slow production and for inferior, even though acceptable, workmanship.

The premium plan pretends to pay in part for the work done, but offers a reward for doing it slowly, and full day pay for doing it not at all or not acceptably.

Otherwise stated, if we assume an increase of speed of production, in piece work the worker is given the saving in wages cost, while the employer takes the saving in equipment cost with the additional profits due to increased plant output. In the Taylor differential piece-rate system the employer establishes an additional reward and penalty as extra incentive to increase the output and the quality. In the premium plan the employer demands all the equipment saving, increased profits, and most of the wages saved in addition. Yet the premium plan is presented by its inventor as a profit-sharing scheme.

It will be noted that the change of piece price is a part of the general scheme of piece pay; in practice it is perfectly available to any piece-work office, and has in itself no connection with the distinctive features of the premium plan, which are as follows: a combination of piece pay and time pay on each operation; fluctuation of wages cost, due to different day rates entering into, but not properly forming a part of, the cost of piece product; the maintainance of day rates among piece workers with their constant readjustment to ages and conditions; unequal pay for identical service by workers of different day rates; an initial investment of "liberal" day pay for less than a day's work, followed by reduced piece work in the hope of lowering the high wages cost resulting; that is, an attempt to recover the amount of the overpay by taking it from the worker's rewards on the piece pay part of his contract, and so reducing his incentive, effort, output, and the productiveness of the shop; the employment of workers with the understanding that there will be no demand for any increase of product per unit of wages beyond the actual day work record at that date for that group of elementary operations, however old and poor the record may be known to be, or however easily the product of an automatic tool may be determined in advance.

More than this would be piece pay, from which it is claimed the premium plan differs radically in avoiding the elements of demand and wage penalty.

We can best compare piece work and the premium plan by assuming them applied to actual manufacturing operations, of which we will consider two opposite classes.

1st.—Fully or partly—automatic machines whose rate of production (when running) is easily determined and almost or quite independent of the worker.

2nd.—Work that depends largely on the skill and effort of the worker, whose speed on new operations increases rapidly.

These are represented in my experience by the punch-press department and coil-winding department of an electrical-manufacturing works under my supervision. For several years these two departments have run for the most part on piece work.

In the punch-press department we will consider an automatic toothing press making two hundred strokes per minute, the blanks being fed in and product removed without stopping the machine. Here piece work assures the following:

So long as work can be found to do, the machine runs continuously at full output without unavoidable delay from loose belts or in waiting for tools, raw materials, helpers, or orders. Delay is reported immediately and the cause removed, for the operator's pay depends on the product and his efforts are directed towards the removal of all obstacles to large production.

The operator learns to look forward, anticipate, and avoid delays, and he keeps all related departments up to their work. While this may call for no physical effort it may demand much attention and energy. If the supply of work fails, the operator goes home at once without question or complaint, for he has not been taught to believe that his mere presence in the shop is worth a fixed time rate. If a high-priced day worker from another department be placed upon a press, he is usually called upon to choose between the temporarily reduced earnings and temporary dismissal, but, if necessary in special cases, he may be paid the value of the piece work and an additional day pay amount, which will be charged, not to the product of the punch press, but to the general expense of the department for whose future need he is retained. This cannot be done until the necessary orders are issued with the proper authority.

The superintendent may rest assured that the equipment cost of product will not be increased by unavoidable delay, or the wages cost raised by high-priced day workers. The price is known immediately and positively. If the production be increased by improvement in construction or method of operating, the piece price will be reduced in proportion, and the worker will receive no benefit from the improvement unless as a reward for suggesting it, of which matter the management alone can judge and must be free handed to act.

Piece work answers all the requirements in this department, while the premium plan offers the most absurd and absolutely purposeless complication of day rates, factors, and variable wage-cost of product.

To begin with, it is not even consistent with the promises of the premium plan, to estimate the proper speed of the press and demand an equivalent of production per dollar wages. Aside from this, however, the system is defective, for the following reasons:

If the day worker were called upon to operate the press he would receive "liberal" day pay and a premium in addition, or, perhaps, several times what the work is worth. Even if the day rates and earnings differ by only a fraction of a cent per hour, dissatisfaction will arise. If the worker were dishonest, he could so charge his time spent on high-premium operations as to receive double pay for a part of it on some other job, which is a defect of any system combining time and piece pay, and ensues when the worker fails to deduct all of the piece-work time from his returns for day pay. Owing to the high day pay, the punch department would carry an operating expense of another department, and its product would be wrongly charged with it. The superintendent would not know whether the operators were running their machines, or drawing the "liberal" day pay of the premium plan. The placing of expensive operators on the work would be in the power of the foremen. Knowledge of the cost of product would be delayed and inaccurate. If the superintendent had any sense of justice he would endeavor to readjust day rates to get them equal without reducing any and without raising the average, which is, of course, impossible, and the effort results in a gradual creeping up of day rates.

I make the proposition that we count the number of strokes of this punch press and estimate its proper output; but Mr. Halsey tells us, regarding such rate setting, that he has "met very few mechanics who believe it can be done," and that piece prices must be made up from day work records. Mr. Taylor, however, has shown that it can be done, not only on the punch press, but on the planer and lathe and on nearly all general shop work, with sufficient accuracy to remove all need of rate cutting, not only in piece work, but even (as he proved) in the intensified differential piece-rate system. In this class of work the premium plan must fail, because it lacks penalty and introduces time pay. This represents the rapidly growing class of work, which already includes most of the operations of a modern general shop and is in the direction of modern progress as product becomes specialized and equipment automatic.

In the coil-winding department we have somewhat different conditions. Piece work is paid on all manufacturing work, but there is a proportion of repair work, which must be paid by the hour. There

are two classes of workers—the special workers and the "allround" experts. The special workers, who have very low and merely nominal day rates, do only piece work, while the "allround" men who alone do both day work and piece work, have much higher rates. Here, again, the conditions are what they should be—each paid his value at that work at which he is employed at the tme.

In this department, on new work, the time required for an operation cannot always, as yet, be accurately foretold, and speed of production depends largely on the skill and effort of the worker and increases rapidly for some time. If piece pay be used, rate reduction in some form is necessary.

The writer was confronted some years ago with the problem of rate setting in this department. His first intention was to change the department to day work, each worker to receive a day rate equal to his average earnings. This was met by a general protest from foremen and workers who claimed that day pay would take the interest and life out of the work. In this field, if any, the premium plan should succeed. What has it to offer?

1st.—It is impossible to pay the high day-rate men full pay for a small day's work, and a premium in addition. Mr. Halsey has not told us what to do in such cases. It appears to be a fatal defect in the premium plan.

2nd.—In paying even a little more per piece to one worker than to another, the premium plan would defeat the chief purpose of the piece pay in this department, and could not fail to cause friction and jealousy in place of rivalry and interest.

3rd.—The premium plan gives us a complication of entirely unnecessary day rates, factors, and limits among the piece workers.

4th.—As to rate reduction, the premium plan proposes a never-ending process of paying less per piece the faster the production on all work (which is rate cutting), as a substitute for periodical rate reduction, which is now necessary on only a few of the operations even in this department, and is rapidly dying out as the piece-work office accumulates data and gains experience.

Moreover, this reduced piece price does not even abolish the need of periodical rate cutting, but merely postpones it the longer the smaller the premium factor, and, by pretences and promises, makes it more difficult or impossible at a later date.

Finally, even if this reduced piece price were of value it could be utilized by our present piece-work office, without any change of system whatever, on those operations only where it is required.

We cannot expect an operator to put forth the same effort for the one-cent-per-piece premium as for the three-or-four-cents-per-piece incentive of piece work, and we cannot consent to cripple our piece-pay system on all work in a vain attempt to profit on a small and decreasing number of operations.

Piece work in this department is of great value in simplifying cost keeping and pay sheet, in valuing product, in ensuring full output, and in its effect on the workers. Rate reduction is avoided as far as possible by intelligent rate setting, but, where necessary, the piece price is reduced at definite and understood intervals, or is guaranteed for a given period of time or for a large order of pieces. I believe that this gives the best results with the least possible loss of incentive.

The premium plan would again fail to meet the requirements; in short, is useless for both classes of manufacture.

In answer to the above it may be objected that the premium plan has succeeded in practical application. In this connection it may be of interest to examine and compare the essential features and the records of actual performance of the Taylor differential piece-rate system and Mr. Halsey's premium plan.

It will be noted that Mr. Taylor and Mr. Halsey have each claimed the discovery of a system for general shop use that will remove all cause of contention between works and worker. Each has tested his plan by years of actual use in shops of unquestioned standing; each has exhibited his results in an apparently convincing manner. Yet these two systems are absolutely opposite and contradictory in every essential, and one or both must be wrong for general use.

Both are extremes, but on the opposite sides of piece pay as ordinarily applied, while Mr. Halsey's plan contains in addition the time-pay mixture.

Mr. Taylor's differential piece-rate plan is dependent on the most thorough methods of valuing labor operations by his elementary rate-setting processes. Mr. Halsey, however, has "met very few mechanics who believe it can be done," and he proposes (in his theory at least) to depend entirely on the actual time results obtained in the shop on each combination of elementary operations, "basing the piece prices on previous day's-work results, as must be done."

Mr. Taylor's plan goes to maximum speed at once by demand and reward. Mr. Halsey's, step by step with a premium. Mr. Taylor's plan is piece work intensified by a factor greater than unity, and places a severe wage penalty just behind the established high speed of production. Mr. Halsey softens piece work by a factor less than unity,

and claims that no penalty is necessary. Is not this due to the premium plan never reaching a really high production?

Mr. Taylor has specially guarded against defective workmanship. Mr. Halsey cannot consistently apply the ordinary safeguard of piece work.

Mr. Taylor's plan seeks high shop productiveness (low equipment cost), and assumes that the management is willing to pay the worker extra per piece for it. Mr. Halsey tells us that, under a fixed piece rate, "increase in production by a workman results in an immediate gain to the employee only," and he therefore pays less per piece the faster the production, or demands a share of the worker's profits.

These two exhibits of actual performance show how useless such records may be as evidence unless they are thoroughly investigated.

In the introduction to the records of results of the premium plan in the *American Machinist* of March 9th, we find the following: "Where the day's-work time has seemed to the superintendent to be excessive, the limit has been placed below the record." Are we to understand that such setting back of the time limit must be credited to a premium plan? The superintendent sets an arbitrary labor value on operations, below that for which they have been done, and demands increase of product for old day wages. It is well known that such procedure will often greatly reduce cost without any system whatever, and the necessity of it exhibits the weakness of the premium plan, with which it conflicts.

The author has given us, not a comparison of piece-pay systems, but a combination of the superintendent and the premium plan on one side, against a day-work condition so poor as to call for the violation of the very first principles of the premium plan. We must ask:

1st.—How much of the cost reduction was due to the general overhauling of day work, and how much to the premium plan?

2nd.—How much greater speed (and reduction of equipment cost) would have resulted from the three-and-four-fold incentive of piece work?

3rd.—Of what use are day rates in piece pay, if the superintendent sets back time limits to suit himself? Why bring in the complication of day pay at all, and why should the management tie its hands with promises to depend on day-pay record in rate setting? The setting back of the day-work time limits amounts to rate cutting, because of the pretensions of the premium plan.

In the premium plan, if the worker has culpably failed to get the work out of his machine, there can be no demand for improvement

or penalty for continued failure, but we must reward him by premium for doing (if he sees fit) what he should have done earlier.

In short, a distinctive feature of the premium plan is the essential absence of that wage penalty which is necessary to the practical working of piece pay. The worker may choose at any time, even during the progress of the work, between day pay or a small premium for extra effort. This is equivalent to "guaranteed day rates" in piece work, which we find by experience must be avoided at all cost, because it destroys the effectiveness of piece pay by annuling the element of penalty and the sense of responsibility.

Piece work depends on wage penalty for its discipline and selective effect in encouraging quick and accurate workers, while weeding out and quietly dismissing the less desirable. Only by wage penalty can the action of piece pay be cumulative and progressive, for without it a point is soon reached where progress is counteracted by the slipping back of productiveness and quality. Only by wage penalty can we hold the works to a high standard of output and quality, and render the operation automatic and "whip-cracking" unnecessary.

The first effect of incentive to effort may be spoiled work; it is absolutely necessary as a means of discipline that the worker be made to replace his labor on it, or, at least, that the employer be free to demand it. It is the management's right in the piece-work contract and its hands must not be bound by premium promises. It is the proper and only means of keeping out inferior workers, with whom the country is flooded; and it is necessary in justice to those workers who have properly mastered their trades. We can accomplish very little without the element of wage penalty, and any system is weak which rewards failure or refusal with full day pay.

Wage penalty for failure in amount or quality of product is not consistent with any system which recognizes an arbitrary time value of the workers and bases remuneration on it. In the premium plan, the withholding of the premium only is equitable and is insignificant in effect. The attempt to tack on a practical wage penalty to the premium plan is inviting a strike among workers, while the management's hand are tied by promises of reward without penalty, under which the men were employed. This, we are told, has occurred in one shop.

It has been claimed that because the premium plan is closely related to day work, and because of its promises of reward without penalty or demand, it can be more easily installed than piece work and with less opposition from the workers.

The writer would reply that the installation of piece work in a day work shop is not necessarily a tearing out and reorganizing process. Each worker may be offered his choice between piece work and day pay on some special class of work. Having chosen, before beginning the work, he must be held to it for gain or loss, and must not under any conditions be allowed to associate ideas of time and piece pay on the operation, and it is in this that the premium plan fails.

When a single worker accepts piece pay and adds to his earnings, others will follow and see the justice of piece work and its advantages to the workers. Such offers are quite as effective as the promises of the premium plan, which must be paid for in full with interest when the practical operation of the shop shows they cannot be lived up to; and when the workers recognize the similarity between giving less pay per piece of product, and the demand of more product per dollar wages, as exhibited in the "setting back" process described in the published records of the premium plan.

It is impossible to live up to the promises of the premium plan and maintain economy of manufacture, yet these promises may be insisted upon and even abused by the workers in matters of rate reduction, of which only the management can judge.

Piece work transactions contain the elements piece price, pieces produced; and time spent. The premium plan adds to these, on every operation, change factor and time rate. This necessarily adds to the clerical processes of collecting and extending the labor returns, and causes variations in the resulting piece and day records, costs, and selling prices. The arbitrary time rate of the worker is usually established while on other work and does not properly enter into the cost of piece product. These variations are, therefore, not the result of greater refinement and accuracy, but the contrary.

Piece work is essentially less complicated and more accurate than any combination of piece and time pay. Wise managers will avoid complications of non-productive processes, especially where they make costs inaccurate and inaccessible. Mixture of time and piece pay in the same transaction is such a complication, and is a characteristic of the premium plan.

It has been claimed that flexible piece price is a "commanding advantage" of the premium plan, yet it is more available to direct piece pay and, further, we note that in the leading exhibit of the workings of the premium plan a fixed 50 per cent. factor is used throughout the works.

It has been suggested that the reduced piece price is especially

justified on self-feeding machines, on which increased output can be obtained without considerable physical effort on the part of the worker. On the contrary, it is on this semi-automatic equipment that maximum output can be most easily and exactly determined and there is least danger of unexpected growth of earnings. It is on such expensive tools that we desire above all to obtain full output, and must have a severe penalty; in short, it is on such equipment that there is least excuse for diminished piece price and an enfeebled system of remuneration. It is on such work that Mr. Taylor's intensified plan has given the best results.

To sum up: The premium plan is combined time and piece pay with guaranteed day rates, extravagant day pay, a lack of penalty, and diminished piece-pay incentive bound together by indefinite promises. It is a reassembling under a new name, of those very elements which piece work is intended to avoid; the combination of those ideas which must be dissociated in the minds of the workers before piece pay can be effective. In my opinion, it is an attempt to get something for nothing by the complication of internal mechanism.

The problem of reducing rates in piece pay without discouragement to the worker must be met fairly and free handed, and no complex system involving time pay can possibly supply in advance engineering data as to the value of elementary operations.

Piece work is broad and flexible in every feature, and sets out to obtain all the advantages of piece pay by the direct application of every means available. It may use the change factors of both Mr. Taylor's and Mr. Halsey's plans, and may utilize Mr. Taylor's piece-rate-seting methods, or day-work observations of actual time, each as best suited to the work in hand.

The premium plan must enfeeble the entire piece-pay system by reduced piece price on all work, or pay more than the work is worth, and is bound down to the use of actual day-work records in establishing piece prices.

It is quite possible for a works, especially if already organized under piece work, to adopt a reduced piece-work system, in which all workers on one class of work are given equal day rates and are kept inflexibly in that department and on that work. The principles, promises, and pretences of the premium plan may be dispensed with, penalty enforced, and time limits set back below day-work records. This may go under the name of "premium plan," but bears no relation to Mr. Halsey's plan as described by him. It is merely a complicated and crippled piece-pay system.

Plain honest piece pay, with penalty for slow work and for work spoiled, is best for the works and for those workers who understand their business; it prevents good workers losing in favor of inferior mechanics, but superior bluffers, who are the only men that have "deep-rooted objections" to piece pay, and they become very scarce in a properly handled piece pay shop.

Shops that are well organized under a good piece-pay system, with full penalty, show much more snap and life and even better workmanship than those which have not received the selective action and discipline of a penalty system.

I confidently believe that properly handled piece-work shops are more secure against labor disputes and strikes, than those which employ on promises and pretences that penalty will not be enforced.

Workers are best employed for piece pay by telling them so plainly without promises and, above all, without elaborate systems with attractive names.

The variable piece price is available to piece pay, but it will not be generally adopted until more definite and quantitative reasons are given for abandoning the direct and effective fixed piece price with its much greater simplicity.

Piece work has, perhaps, in some cases been misapplied through ignorance of its principles, for piece-pay systems are edge tools that must be used intelligently. Mr. Halsey hopes to render them less dangerous by dulling the edge, but in doing so he destroys their usefulness.

The premium plan is the result of a disregard of equipment cost and the assumption that "an increase in production after the price is once cut results in an immediate gain to the employee only."

Of the many purposes and uses of piece work, the inventor of the premium plan has considered only its use in procuring increased physical effort of the worker, which may represent only a small part of its real value. In the premium plan he has forfeited many desirable features of piece pay and has produced an inconsistent and ineffective plan. He proposes to abandon exact and scientific rate setting and returns to the primitive methods of rate guessing.

Mr. Halsey states that the premium plan bears the same relation to piece work as "peace and harmony to discord and dissention," but I cannot find one feature of the premium plan in which it is better than direct piece pay, nor can I find any value returned to the employer to justify the poor investment of full day pay for less than a day's work.

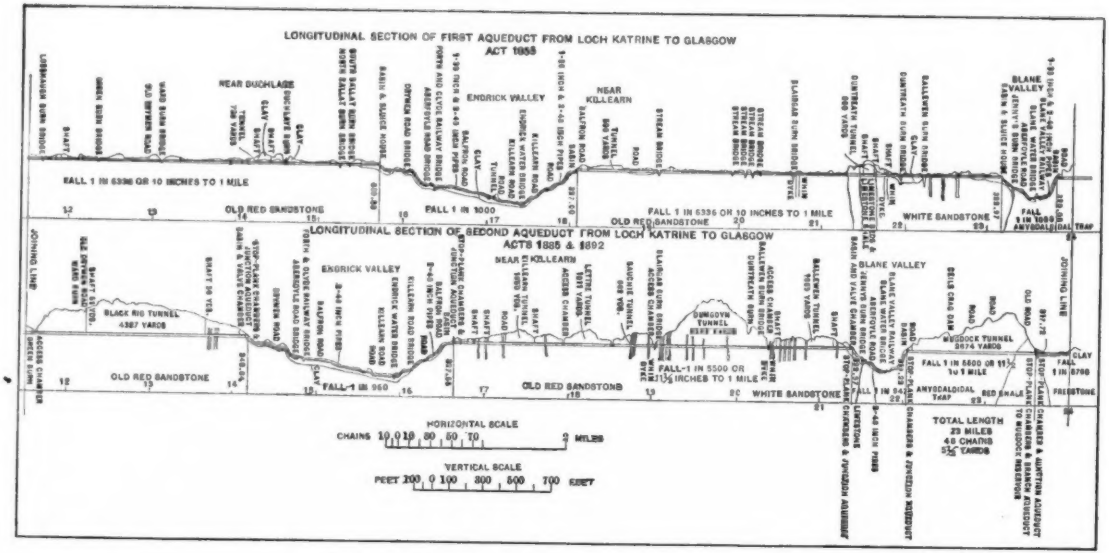
THE WATER SUPPLY OF THE CITY OF GLASGOW.

By Benjamin Taylor.

THE water works of the city of Glasgow afford a striking instance of the extent to which the mechanical progress of the latter half of the century has affected engineering undertakings. If it were simply a pumping system, this would be so immediately apparent and so much to be expected that it would hardly merit comment. But Glasgow is supplied by gravity flow.

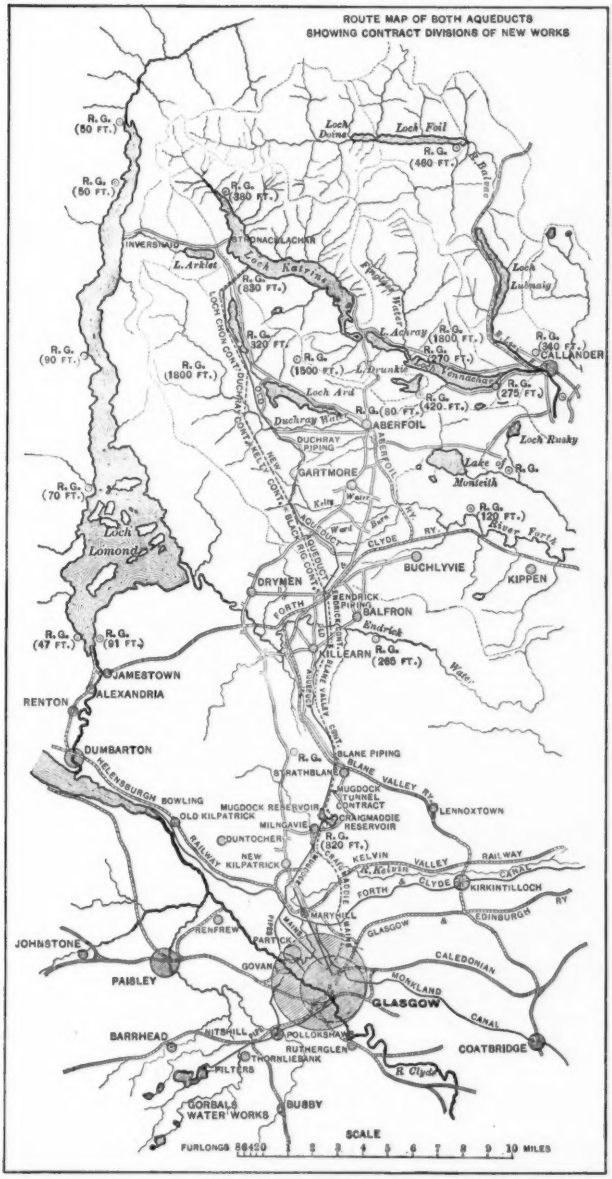
By the foresight of the past generation, for the benefit of the present, the water of one of the most beautiful of the highland lochs is discharged from the heart of the mountains into the heart of the city, at the rate of 50,000,000 gallons per day. This was the limit of the original design in bringing Loch Katrine to Glasgow when the work was planned some forty-five years ago.

The measure of a third of a century of mechanical advance is afforded by contrasting the old aqueduct with the newer one, and noting how improved methods and appliances for engineering construction on a large scale have not only cheapened and facilitated the execution of the work, but have made possible radical alterations in its design. The straightening in the line, shown on the accompanying plan, suggests the marked improvement over the original works by which the new works are characterised throughout. In the first place, the new aqueduct is 1¾ miles shorter than the old, and Mr. Gale has cut a more direct line, and moreover, he has reduced the amount of heavy masonry work to be built by skilfully avoiding the crossing of many deep ravines. There are 7 miles more tunneling in the new aqueduct than in the old, but tunneling is a much simpler operation now than it was forty years ago. By the use of compressed air for driving the drills for boring the shot holes, and by the use of more powerful explosives than gun-powder, the work of tunneling was much simpler on the second aqueduct than the first. Mr. Gale's design was so far different from the first works that the new aqueduct is practically a series of tunnels, and the aim throughout has been to keep the water channel as far as possible under and removed from the action of the atmosphere. The striking mechanical feature of the work is that of 23½ miles of waterway, close upon 19 miles of which are in tunnel and about 3 miles in siphon. The length of each tunnel has,


LONGITUDINAL SECTION OF FIRST AQUEDUCT FROM LOCH KATRINE TO GLASGOW
ACT 1855
LONGITUDINAL SECTION OF SECOND AQUEDUCT FROM LOCH KATRINE TO GLASGOW
ACTS 1885 & 1892
HORIZONTAL SCALE
CHAINS 10 0 10 20 30 40 50 60 70 80 MILES
VERTICAL SCALE
FEET 200 0 100 300 500 700 FEET
TOTAL LENGTH
23 MILES
46 CHAINS
5½ YARDS

LONGITUDINAL SECTIONS OF OLD AND NEW AQUEDUCTS.

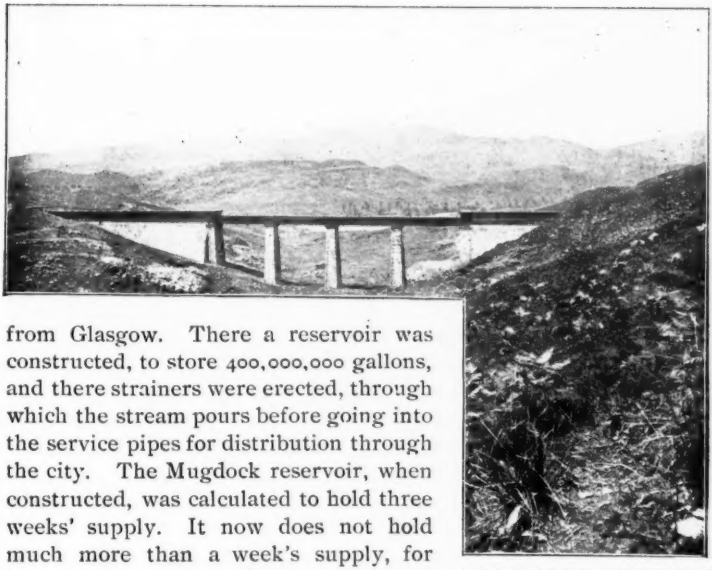
Showing the decrease of surface work and increase of tunnel in the later aqueduct.


ROUTE MAP OF BOTH AQUEDUCTS
SHOWING CONTRACT DIVISIONS OF NEW WORKS
R. G. (50 FT.)
R. G. (50 FT.)
R. G. (90 FT.)
R. G. (70 FT.)
R. G. (47 FT.)
R. G. (91 FT.)
R. G. (380 FT.)
R. G. (460 FT.)
R. G. (830 FT.)
R. G. (320 FT.)
R. G. (1800 FT.)
R. G. (1500 FT.)
R. G. (1800 FT.)
R. G. (1270 FT.)
R. G. (340 FT.)
R. G. (275 FT.)
R. G. (80 FT.)
R. G. (420 FT.)
R. G. (120 FT.)
R. G. (285 FT.)
R. G. (920 FT.)
Loch Duine
Loch Foil
R. Leven
INVERSNAID
ST. CATHERINES
L. Arklet
Loch Katrine
Loch Lubnaig
L. Achray
L. Drunkie
Loch Ard
CALLANDER
Duchray Water
Duchray Hill
ABERFOIL
DUCHRAY PIPING
GARTMORE
Loch Rusky
Lake of Menteith
Loch Lomond
BUCHLYVIE
KIPPEN
DRYMEN
BALFRON
KILLEARN
JAMESTOWN
RENTON
ALEXANDRIA
DUMBARTON
STRATHBLANE
BLANE PIPING
BLANE VALLEY RY.
MUGDOCK TUNNEL CONTRACT
MUGDOCK RESERVOIR
CRAIGMADDIE RESERVOIR
LENNOXTOWN
OLD KILPATRICK
MILNGAVIE
DUNTOCHER
NEW KILPATRICK
KELVIN VALLEY RAILWAY
FORTH & CLYDE CANAL
KIRKINTILLOCH
EDINBURGH & GLASGOW RY
MARYHILL
PARTICK
GOVAN
PAISLEY
JOHNSTONE
RENFREW
CALEDONIAN
MONKLAND CANAL
GLASGOW
COATBRIDGE
BARRHEAD
NITSHILL
POLLOKSHAWS
RUTHERGLEN
THORNLIEBANK
R. Clyde
FILTERS
GORBALS WATER WORKS
BUSBY
SCALE
FURLONGS 8 6 4 2 0
1 2 3 4 5 6 7 8 9 10 MILES

of course, been determined largely by the configuration of the ground; but wherever possible the length was restricted to one mile, so as to facilitate the removal of the spoil during construction. There are only five bridges on the new aqueduct, and the valleys of the Blane and the Endrick are crossed by siphons 3 miles 8 chains in length. To be more specific, the new aqueduct is 23½ miles in length, of which 18 miles 78 chains are in tunnel, 1 mile 34 chains in cut and cover, and 3 miles 8 chains in siphons. It is larger than the old, being 12 feet wide by 9 feet high, and has a concrete invert throughout to ensure the passing of the maximum quantity of water.

At the time when the original works were built, two things were not foreseen. One was the resistance to be afforded to the stream by over thirty miles of piping; the other was the enormous growth of the population to be supplied.

The population was then about 360,000, and it was calculated that, up to the end of the century, the increase would be at the average rate of 8,000 per annum. The drain to begin with was only 8,000,000 gallons per day. But the actual annual increase in the population has gone up, year by year, until it is now at the rate of 19,000 per annum, whilst the consumption of water per head has continuously increased, through the extension of factories, the provision of public baths, lavatories, and washhouses, the erection of baths in practically all but the very poorest of houses, until it is now 50,000,000 gallons per day. In forty years, then, the consumption has increased more than six-fold, and has reached the limit contemplated in the original design. But, as a matter of fact, the channels devised for the flow of 50,000,000 gallons per day were found in practice able to transmit only 42,000,000 gallons. It was not known, when the aqueduct was first constructed, how much the roughness of the inside of the pipes would influence the discharge. Darcy had not then instituted his famous experiments to determine the velocity of the flow of water in channels. It was not until 1880 that, by careful measurement, it was found that the maximum discharge of the aqueduct was 42,000,000 gallons per day, and that to pass even that quantity the sides of some of the trough bridges must be raised. But in 1852 it was estimated that in 1900 the consumption would not exceed 30,000,000 gallons. In 1855 the Parliamentary powers for the Loch Katrine scheme were obtained, and in 1859 the works were completed and the water was turned on by the Queen. By a long chain of aqueducts, tunnels, and siphons the stream was brought through hills and across valleys and rivers to Mugdock, on the side of the Kilpatrick Hills, some five or six miles



AQUEDUCT NEAR COULEGARTON

from Glasgow. There a reservoir was constructed, to store 400,000,000 gallons, and there strainers were erected, through which the stream pours before going into the service pipes for distribution through the city. The Mugdock reservoir, when constructed, was calculated to hold three weeks' supply. It now does not hold much more than a week's supply, for in 1898 the average daily consumption was 52,630,000 gallons, and this year the average will be over 53,000,000 gallons, at the normal rate of increase. And here it may be remembered that the consumption is estimated by Mr. James M. Gale, the eminent water engineer of the city of Glasgow, at 55 gallons per day per head of the population, viz., 34 gallons per head for domestic purposes and 21 gallons per head for trade and public purposes.

The extensive works now approaching completion are intended to bring the daily supply up to 110,000,000 gallons, practically two and one-half times the amount which the original works have proved equal to, for although 42,000,000 gallons is the nominal supply of the old aqueduct, the actual flow does not exceed 40,000,000 gallons per day. Not all of the water supply of Glasgow is derived from Loch Katrine. Among the water companies bought up by the corporation was one called the Gorbals Gravitation Company, which took the water from a stream flowing out of the hills in the Barrhead district to the south of the city. These works are still kept up by the corporation for the service of a portion of the area on the south side of the River Clyde. They provide about 5,000,000 gallons

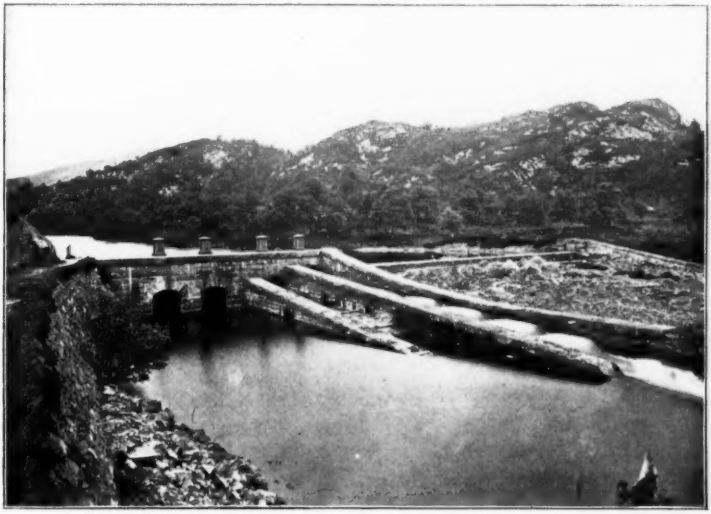
LOCH KATRINE, THE SOURCE OF THE SUPPLY.
The farther end from the water works, showing Ellen's Isle and Ben Venue.

per day.* The area of the Glasgow corporation, as water commissioners, is about fifteen miles from north to south and about eleven miles from east to west and includes a population of over a million.

Every tourist in Scotland of course knows Loch Katrine, which Sir Walter Scott immortalised in "The Lady of the Lake." It is a lake of surpassing beauty, and its waters are of remarkable purity. It is also in a practically uninhabited district, so that it has been comparatively easy to prevent the drainage of the few houses in its water shed from finding its way into the lake; no bathing is allowed, and the little pleasure steamers, plying for the tourist traffic, may not allow any refuse or impurity to pass. Moreover, it is in a region with a high average rainfall, and the hills around are so bare and precipitous that the streams which feed it carry with them very little vegetable or foreign matter. The drainage of Loch Katrine is about 23,200 acres, and of its reserve feeder, Loch Arklet, about 3,000 acres. The top water level at which 110,000,000 per day can be drawn off is 373 feet above the sea. The lake was tapped about five miles from the

* About 2,500,000 gallons per day are also drawn from the river Clyde for the use of public works.

Trossachs end, and from the outlet to the reservoir at Mugdock the old aqueduct is 25¾ miles in length. For several miles it had to be driven through hard rock of a hill that separates Loch Katrine from Loch Chon and then cut through a long, rocky slope, after which ravines and rivers had to be crossed by tubular bridges. On this aqueduct there are twelve miles of tunneling, ten miles of open mason-work and bridging, and four miles of tubular bridging of streams and valleys. This aqueduct has an arched roof, is 8 feet high by 8 feet wide, and has a fall towards Glasgow of 10 feet to the mile. At the outlet from Loch Katrine, the works consist of a stone basin, 55 feet by 40 feet, with three cast-iron sluices between which and the mouth of the tunnel is a wire-netting strainer to arrest fish and all floating material. At the lower end of the loch was constructed a masonry dam, with two sluices, two salmon ladders, and a waste weir. This dam controls over 6,000,000,000 gallons. The other end of the aqueduct is the reservoir at Mugdock, which was formed by embanking a natural valley, and is 62 acres in extent. The water is not drawn off from this reservoir through the embankment, but by a tunnel cut through the hillside. Before entering this tunnel for distribution through the city piping, the water draws off through sluices into a well 40 feet in diameter by 53 feet in depth, at the bottom of which



SLUICES AND SALMON LADDERS AT THE OUTLET OF LOCH KATRINE.

are regulating valves. From this well two sets of pipes lead away, each 3½ feet in diameter, before entering which again the water is strained through copper-wire netting.

These gigantic and unique works were completed in the autumn of 1859; but not very many years passed before it was foreseen that their capacity would prove insufficient for the needs of the community, at the rate at which these are growing. Without going over all the history of the deliberations and developments, it will suffice to say that in 1882 the corporation decided to duplicate the supply, by building an entirely new aqueduct. The necessary powers were obtained, and work was begun in 1886, the intention being to proceed by stages and at a moderate pace which would involve no call on the ratepayers. To double the discharge from the lake to the city involved three things—the construction of an entirely new aqueduct for the whole district, the construction of an entirely new and larger reservoir to hold the additional quantity on the outskirts of the city, and an enlargement of the storage capacity of the lake itself. The enlargement of the supply basin is effected by raising the high-water level of Loch Katrine to enable it to retain more of the hill-drainage, and in the future, as need arises, it will be further enlarged by drawing off the waters of Loch Arklet. This is a small loch, lying between Loch Katrine and Loch Lomond, which at present discharges itself by a noisy stream into Loch Lomond at the famous Falls of Inversnaid. It is, however, now marked off as an assistant reservoir in reserve for Loch Katrine, into which loch it will be made to flow, when needed, in the perhaps not very distant future, at the rate of an additional 10,000,000 gallons per day. The original works, with city piping, cost £2,500,000. The extension works will cost £1,500,000.

The act of 1885 gives power to raise the level of the loch by five feet, and also to raise the level of Loch Vennacher, from which compensation water is provided to the riparian owners on the River Leith. The potential capacity of Loch Katrine will be 9,849,000,000 gallons, and that of Loch Arklet 2,059,000,000 gallons; but the joining of the two lakes by means of a tunnel is deferred until the city is in need of the additional supply.

In the meantime the original outlet from the lake is being used for both aqueducts, but the contract for the last section of the new works has recently been let—one, namely, for the construction of a new outlet and a second tunnel through the hill that separates Loch Katrine and Loch Chon. When that is finished, the new aqueduct will stretch direct from the lake to Craigmaddie reservoir, which lies to the east

of the old Mugdock reservoir. The two aqueducts run side by side for a considerable part of the distance, and are nowhere more than 1½ miles apart; and at several points are connecting aqueducts, by means of which the stream in one may be diverted into the other should occasion arise. At several points, too, the two aqueducts cross each other.

The longest tunnel on the new aqueduct is that known as the Kelty tunnel—2 miles 5 furlongs long, and 250 feet below surface level. It was driven from both ends, and from two shafts about 60 feet deep. This tunnel took four and one-half years to complete, and when the

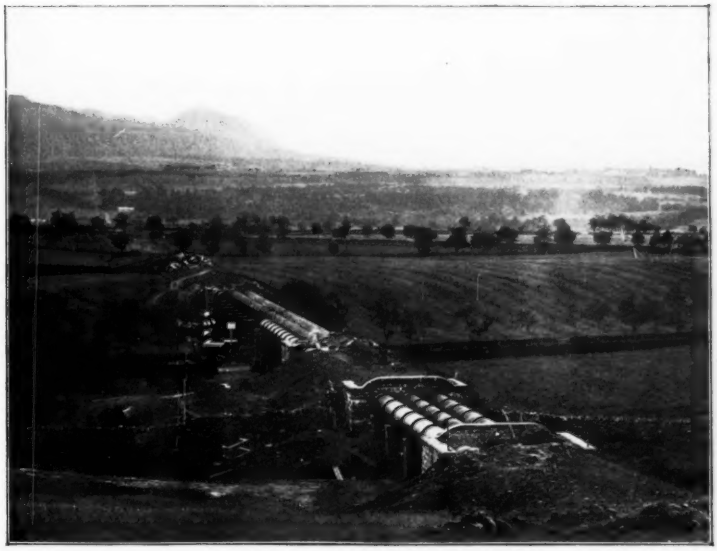
MUGDOCK RESERVOIR AND GAUGE BASIN.

two faces met there was only a couple of inches of difference of level. The drilling of this and the other tunnels was partly by hand and partly by power rock-drills. Gelignite was the explosive mostly used. The first tunnel to be completed is actually the last on the aqueduct, being at Mugdock. This tunnel was finished as long ago as 1890, and was at once brought into use by means of "stop planks," so as to permit of the old tunnel being repaired. The small proportion of "cut-and-cover" work in the new aqueduct has been in consequence of the rock coming so close to the surface that it is as easy to drive a tunnel as to open downwards. And this is why Mr. Gale cut

a shorter route for the new line. In some of the cut-and-cover lengths, the ground is so hard that no lining has been necessary, only an arched roof. In some cases, the side walls had to be lined; in other cases, complete lining has been necessary. The general section in these cases is an invert of 9 inches, side walls 18 inches and a batter of 1 in 12, with an arch of 18 inches thick, covered with a three-quarter-inch layer of cement on top. In rock cuttings, 12-inch walls sufficed, but when the water run of the aqueduct comes above the level of the ground the side walls are three feet thick.

Of the two siphons already mentioned, the one over the Endrick valley is 2 miles 34 chains long. There are four pipes, each 48 inches diameter, laid at an inclination of 1 in 1,000; the fall is gradual to 280 feet, though the rise on the other leg of the siphon is very steep. There are three connecting bridges, one over the Forth & Clyde Railway, one over the public road, and one over the River Endrick—all

DUCHRAY VALLEY, SHOWING THE LINE OF THE AQUEDUCT.



PIPING IN THE ENDRICK VALLEY.

similar in design, and with spans varying from 36 feet to 84 feet. The pipes are carried across these bridges in cast-iron saddles, laid on beams. A scour-pipe, 18 inches diameter, with ordinary sluice valves, is at the lowest part of the siphon, and discharges into the Endrick. The piping not only passes under several roads, but also crosses a siphon of the old aqueduct; the construction is similar in the Blane valley siphon, which is 1,194 yards long, but has a fall of only 120 feet. For the greater part of the length of the siphon the pipes are bedded into the ground, with a bank 2 feet 6 inches deep, but at some points they are supported on masonry piers, 2 feet to 6 feet high. The maximum grade is 1 in 5, and the most acute curve is of 288-feet radius. The water passes from the aqueduct into the siphon in a valve chamber 30 feet by 12 feet by 16 feet, with concrete walls, backed by puddle to resist the pressure. The centre of the pipe is 3 feet 6 inches below the invert of the aqueduct and the inlet end is fitted with an open-frame sluice valve. There is also a 9-inch pipe to the siphon to carry off any air that may come in with the water. At the other end of the siphon the pipes discharge into a basin 30 feet wide, to the south of which again is a stop plank and overflow chamber.

On the whole line of the new aqueduct there are ten bridges of varying spans up to 52 feet 6 inches—that of the one across the Duchray water. These bridges are for the most part of concrete faced with whinstone and Loch Arne granite. They are comely structures which in no way mar the beauty of the scenery.

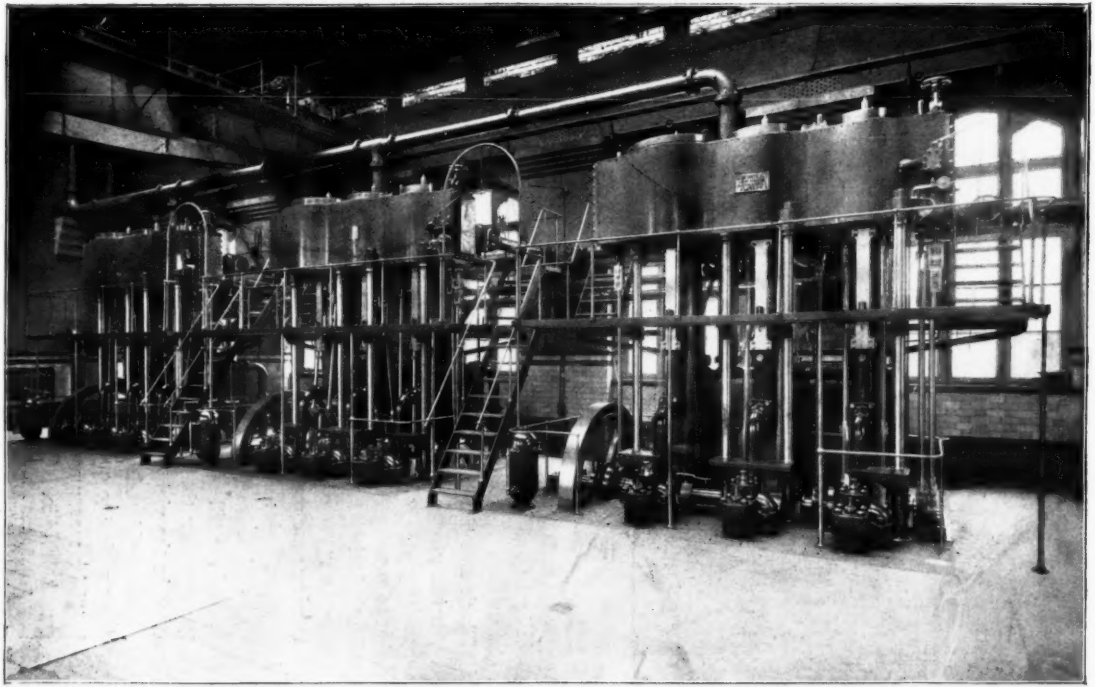
Undoubtedly the most difficult portion of the new works has been the Craigmaddie reservoir, the first contract for which was £105,000, but the ultimate cost of which was £300,000. Excavations had to be carried to a depth of 200 feet before a good bottom could be found for a puddle wall. Whinstone rock was found at no great depth, but so intrusive Mr. Gale would not take it as bottom but drove right through the whinstone to sandstone and shale beds beneath.

This new reservoir curves round three sides of a hill and is quite close to the old Mugdock reservoir, with which it can interchange supplies. It has a water area of 88 acres and a storing capacity of 717,000,000 gallons.

The inlet works of the new reservoir consist of an aqueduct capable of conveying 110,000,000 gallons per day from the south end of the Mugdock tunnel at which the waters of Loch Katrine emerge after their long journey through the hills. The two tunnels are connected at their outlets by a junction aqueduct and stop-plank chambers, so that the flow of either or both of the aqueducts may be directed to either or both of the reservoirs.

At Springburn, 8½ miles from the reservoirs, is a pumping station and a high-level tank for the purpose of maintaining a high pressure on the elevated lands around the city. This high-level reservoir is 369 feet above sea level. It costs 21 shillings 6 pence per 100,000 gallons to bring Loch Katrine into Glasgow and 35 shillings 6 pence per 100,000 gallons to work Springburn pumping stations. The pumps throw 500 gallons per minute a height of 160 feet into the reservoir, which is capable of holding 750,000 gallons. Besides this, there is a station in the east end of the city for the supply of water under high pressure for hydraulic-power purposes, the hoists and hydraulic presses in the city being very numerous. There are three sets of pumping engines of 200 h. p. each, four Lancashire boilers with economizers, and two hydraulic accumulators.

Each engine can pump 230 gallons per minute with a steam pressure of 120 pounds against an accumulator pressure of 1,120 pounds per square inch. The engines work independently and each delivers into one of the 7-inch mains which are laid throughout the district of supply in two separate circuits. At certain connecting points are



HYDRAULIC-POWER PUMPING STATION, IN CONNECTION WITH GLASGOW WATER WORKS.

Three sets of pumping engines, 200 h. p. each. Steam pressure, 120 lbs. Accumulator pressure, 1,120 lbs
Made by Messrs. Hugh Smith & Co., Glasgow

STRAINING WELL AT MUGDOCK RESERVOIR.

valves which admit of the system being worked as one circuit, and connected with the 7-inch mains are 5-inch and 6-inch pipes provided with valves by means of which any street can be cut off the general circuit. There is a tank capable of holding 200,000 gallons which is built of ¾-inch and ⅝-inch iron plates and is divided into two portions. In the construction of this huge reservoir the plates were subjected to very searching tests. Each plate was supported on its flange ends and a weight of five tons applied to the centre; upon a bar not exceeding 6 inches wide on the face, the maximum deflection was not allowed to be more than one-eighth of an inch.

The following note on the bridges of the aqueduct is from a communication by Mr. Gale:

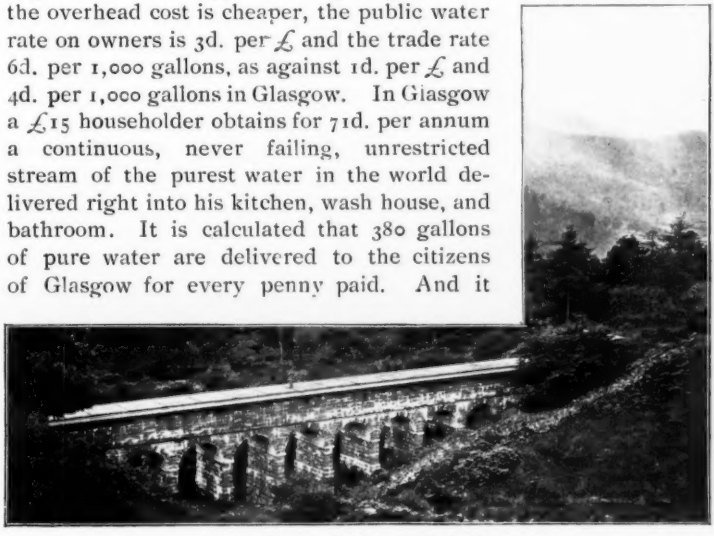
"It was at first intended that the new aqueduct should follow pretty closely the line of the old one and in designing the works the best kind of bridge for carrying the water-channel across ravines on the line, especially those in the vicinity of Coulegarton and the Duchray water had again to be considered. There are five of these bridges, varying in length from 372 feet to 996 feet, and of a total length of 2,907 feet.

* * * "The masonry bridges on the line of the old aqueduct have given much trouble. On the occurence of severe frost, the top courses of the masonry are lifted from their beds, causing extensive leakages which have to be made good by cementing inside. This, however, has been permanently cured as regards five of the bridges north

of the Endrick valley by lining them inside with cast-iron plates. It was therefore resolved that, instead of following the old line, the new aqueduct should consist throughout of a series of tunnels and that the water channel be kept as far as possible underground and removed from the action of the atmosphere."

The last tunnel—that through the ridge which separates Loch Chon from Loch Katrine, 1 mile 3 furlongs long—was driven through in June, 1898, and is being rapidly completed along with an inlet similar to that of the old aqueduct. There remains, then, of the whole great design the new outlet works at the lower end of Loch Katrine, which include a new masonry dam by means of which the water level of the loch will be raised 5 feet, bringing its storage capacity up to 9,849,000,000 gallons. The contract for this last section of the work will be completed in the course of the present year.

According to figures compiled by the city chamberlain, Dublin has the cheapest water in the United Kingdom, the cost working out at 0.857 of a penny per gallon per annum. Glasgow comes next however, at 0.963d. Then comes Dundee, 1.077d., Edinburgh, 1.340d., Newcastle 1.860d., Leeds 1.875d., Birmingham 2.453d., Manchester 2.476d., Bradford 2.770d., Liverpool 3.062d. But in Dublin, though the overhead cost is cheaper, the public water rate on owners is 3d. per £ and the trade rate 6d. per 1,000 gallons, as against 1d. per £ and 4d. per 1,000 gallons in Glasgow. In Glasgow a £15 householder obtains for 7½d. per annum a continuous, never failing, unrestricted stream of the purest water in the world delivered right into his kitchen, wash house, and bathroom. It is calculated that 380 gallons of pure water are delivered to the citizens of Glasgow for every penny paid. And it



AQUEDUCT BRIDGE, DUNTREATH.

THE END OF THE AQUEDUCT, MUGDOCK RESERVOIR.
Showing mouth of tunnel and gauge basin.

is water of such peculiar softness that the householders of Glasgow can pay their water rate out of what they save on soap.

Loch Katrine water is not only soft, it is remarkably bright, clear, and free from vegetable matter, because of the bare and precipitous character of the hills which drain into the loch. It is uniform in colcur, temperature, and quality, is absolutely free from pollution and must remain so because the corporation have now bought up the building rights of the whole drainage area; it needs no filtration and is practically unaffected by the change of seasons. Sir Walter Scott has sung the magic beauty of this lake, but its greatest beauty is after all the beauty of utility, the sustaining influence of its waters supplied to a million thirsty beings, and to thousands of insatiable factories thirty-five miles away.

ELECTRICITY IN THE MINES AT CRIPPLE CREEK.

By Thomas Tonge.

CRIPPLE CREEK is perhaps the only gold-mining district in the world where a miner can go to his work in an electric street-car, descend the mine in an electric hoist, keep his mine dry by an electric pump, do his work by an electric light, run drills operated by electric air-compressors (possibly, in time, to be superseded by direct electric drills), and fire his shots by electricity from a switchboard remote from the point of explosion.

The Cripple Creek district is contained within an area of a little more than six square miles, consisting of rolling hills and small valleys and gulches, at an average elevation of over 9,500 feet, with towns and villages at short intervals, such as Cripple Creek (altitude 9,510 feet), Anaconda (9,450 feet), Victor (9,500 feet), Altman (10,625 feet—the highest incorporated town in the United States), Independence (10,300 feet), etc. Among the intervening elevations are Globe Hill (10,740 feet), Bull Hill (10,780 feet), Battle Mountain (10,640 feet), Beacon Hill (9,720 feet), Raven Hill (10,350 feet), Gold Hill (10,300 feet), etc.

In this limited area there are upwards of one hundred and fifty shipping gold mines, fifteen of which produce over 1,000 tons of ore each per month. The gold production of Cripple Creek, in round numbers, by years, has been as follows:

1891.....	$200,000	1895.....	$8,100,000
1892.....	600,000	1896.....	10,000,000
1893.....	2,300,000	1897.....	12,000,000
1894.....	4,000,000	1898.....	14,000,000

Computations, made by reliable persons at the end of July of the present year, of the amounts paid out in dividends to the shareholders of Cripple Creek mining companies showed that the total had reached over $8,000,000. The total for the present year, at that time, was already over $1,250,000, with probability that the record of nearly

$2,600,000 during 1898 will be exceeded this year. These figures relate only to the dividends actually paid by companies, and do not include the profits of mines owned and operated by private individuals, or the profits made by lessees, which, if they could be accurately ascertained, would very much augment the above amounts.

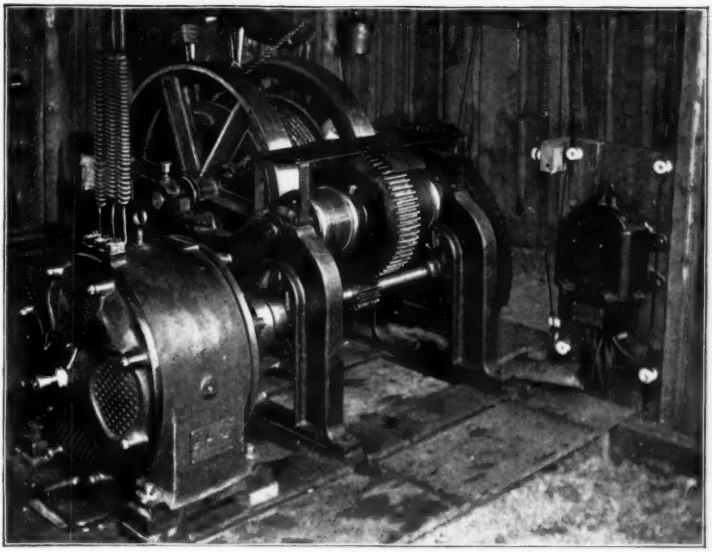
The whole Cripple Creek district, which in 1891 was a remote mountain pasture with less than a dozen inhabitants, has now a population of nearly 50,000.

During 1894 a narrow-gauge line, known as the Florence & Cripple Creek Railroad, forty miles long, was built at a cost of $500,000 of Colorado capital, from Florence on the Denver & Rio Grande Railroad, tapping Cripple Creek from the south; since that time it has been extended so as almost to encircle the limited ore-producing district.

In 1894 also, a standard-gauge line, thirty miles long, known as the Midland Terminal Railroad, was built at a cost of $25,000 per mile, from Divide, on the line of the Colorado Midland Railroad, tapping Cripple Creek from the north, the last fourteen miles being a circuitous route almost circumnavigating the mining district.

On account of engineering difficulties, these competing steam railroads (running frequent suburban trains) only *encircle* the cluster of gold-bearing hills, leaving a comparatively extensive centre in which steep wagon roads gave the only access to numerous rich mines, employing large numbers of men. The miners employed in such mines, therefore, had either to live in small and unsuitable cabins near their work or, if living in the towns, had the choice of taking a very laborious and exhausting climb to reach their work, or of keeping a saddle horse; many of them chose the latter alternative. Exclusive of the miners, there is very considerable travel by other people to and from the mines.

This condition of affairs led to the organization of the Cripple Creek District Railway Company and the building of an electric street-car line, which, commencing at the north end of the town of Cripple Creek (altitude 9,510 feet), traverses in a meandering course, on account of engineering difficulties, the entire centre of the district to Victor (altitude 9,500 feet) at the south end. The line is a little more than six miles long, and presents a constant succession of grades and curves; at a point known as Midway (10,514 feet above sea level and consequently 1,000 feet higher than its termini at Cripple Creek and Victor), it affords a magnificent panorama of the adjacent hills dotted with mines and waste dumps. The round trip, including



A 10 H.-P. ELECTRIC MINE HOIST.

THE GOLDFIELD ELECTRIC-POWER PLANT, PARTLY COMPLETED.
The mines on the hill are the Golden Cycle and the Theresa.

numerous stops, occupies about an hour. It is made at an average speed of about twelve miles an hour, which it is expected will be increased. The electricity is generated by water power at Lake Moraine (altitude 11,300 feet) on Pike's Peak and transmitted by wire nine miles to a distributing station midway on the line of the electric railway.

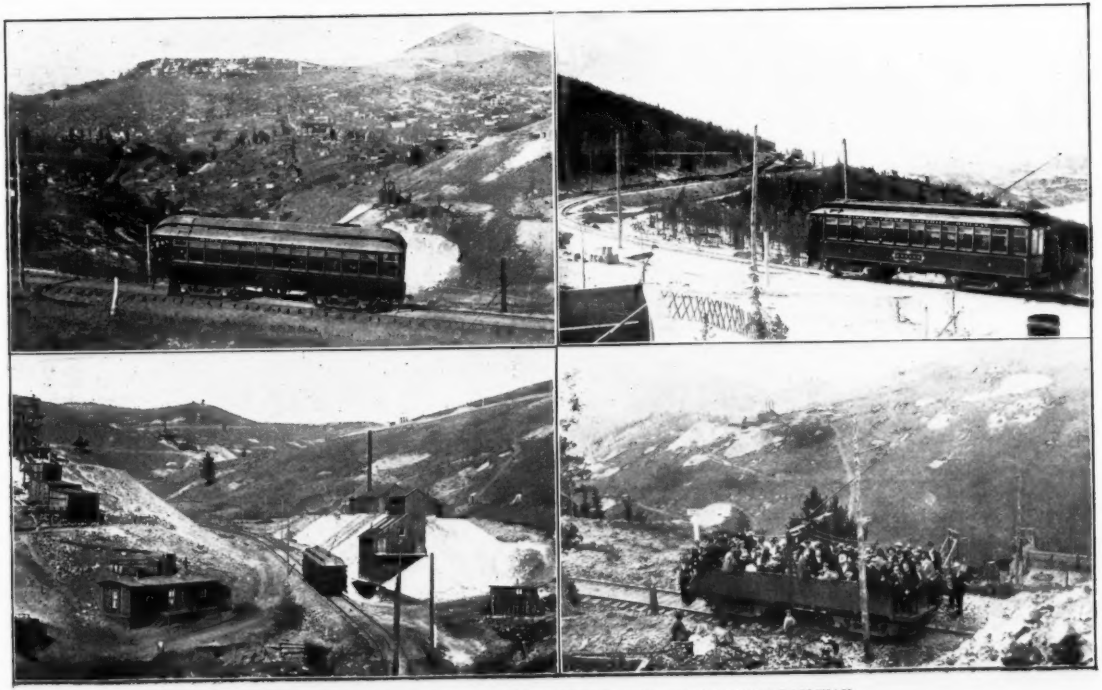
This enterprise recently passed into the hands of a syndicate of capitalists at Colorado Springs, Colo., large owners of some of the most profitable Cripple Creek mines, and it is their intention to make many improvements and extensions, including an extension of the line from Cripple Creek to Colorado Springs, a distance of 32 miles.

It is obvious that the sinking and operating of the mines of Cripple Creek have involved the expenditure of a large amount of power, which for the first seven years of the mining history of the district was derived exclusively from steam and therefore demanded vast supplies of fuel and water. As the mines are usually high up on the steep hill sides or summits the transportation of such fuel and water means very heavy cost.

Within thirty miles to the southward of the Cripple Creek district is the Cañon City coal field, 5,000 feet lower in altitude. The use of steam power, therefore, necessitated hauling the coal by railroad up grade to one or other of the various stations in the Cripple Creek district and thence by wagon up steep roads to the mines.

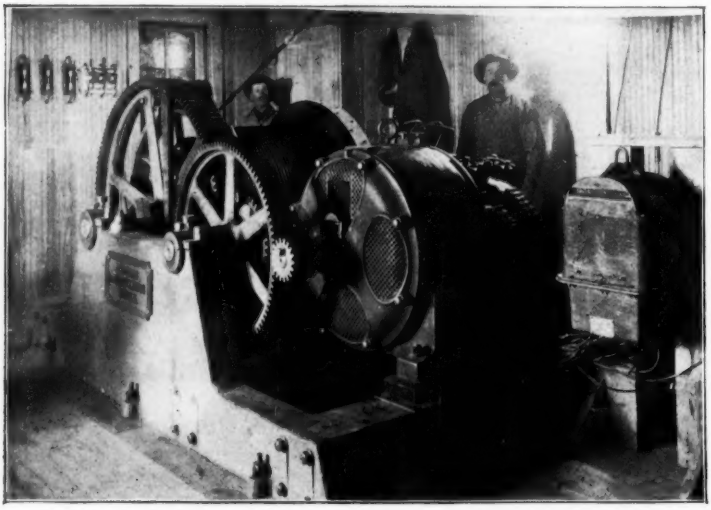
Cripple Creek mines have usually been "dry," and even in the exceptional cases where water has been struck at considerable depth the supply has been unreliable, as the driving of numerous long tunnels at great depth has had the effect of draining the comparatively few mines that had water. Moreover, there are no local streams of volume. Speaking generally, therefore, the steam hoists, etc., of the Cripple Creek mines have been depended upon water hauled by wagon up steep roads to the mines, from springs, etc., in the valleys. The high altitude—averaging 10,000 feet—increased greatly the risk of freezing and consequent stoppage in winter. Moreover, in many cases, the water has cost fully as much as the fuel.

Again, the class of steam mining machinery in general use is somewhat notorious for its consumption of steam, for which reason from one to five boiler horse power are required for every horse power produced by the machinery. The water consumption, as well as the coal consumption, for the power produced, is therefore very high in comparison with the same figures for more modern types of machinery.



VIEWS ON THE LINE OF THE CRIPPLE CREEK DISTRICT ELECTRIC RAILWAY.

The leasing system is very common in Cripple Creek. Prospectors of limited means and lessees for comparatively short terms, with ultimate success uncertain, were not in a position to purchase and put in steam plants with subsequent heavy expense of water and fuel.



30 H.-P. MOTOR AND HOIST, MATOA MINE.
The space occupied is less than one tenth of that required for the corresponding steam plant, including water tanks, coal bins, etc.

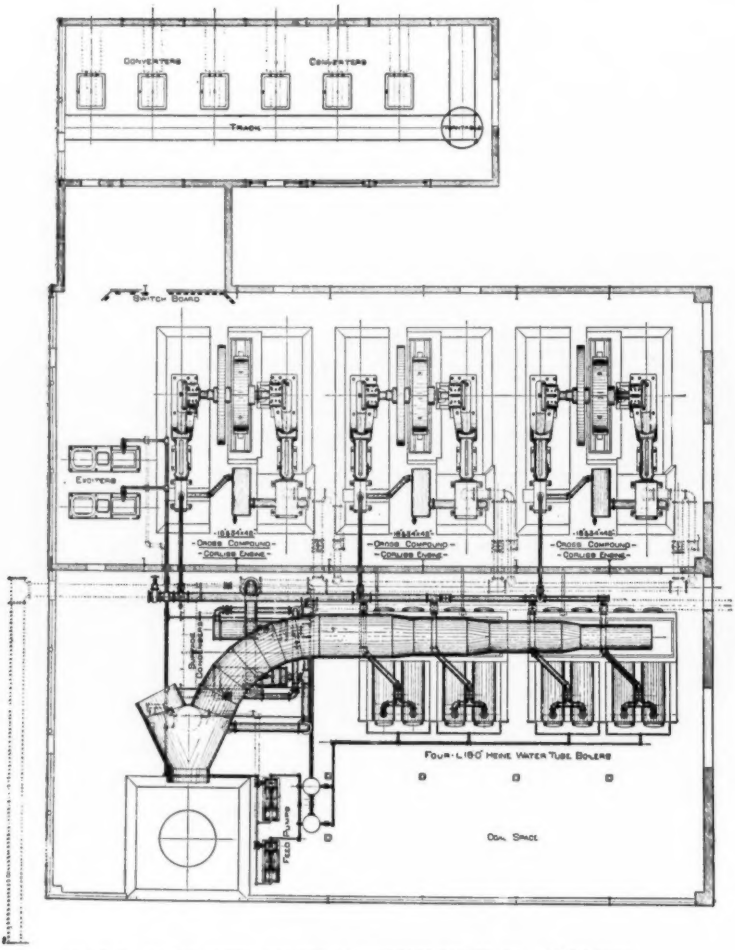
In July, 1888, the first electric hoist for mining purposes was started up in connection with the Western Tunnel, Aspen, Colo., and is still in operation. It was afterwards connected also with an adjacent shaft for hoisting purposes, the power for this and for additional motors subsequently installed being supplied from Hunter Creek, where a generator of 60 h. p. was first placed, and later another of 125 h. p. Early in 1893 another plant of nearly 500 h. p. was established on Maroon Creek, Aspen. To-day there are at Aspen electric motors, operated by water power, aggregating over 700 h. p. They are utilized for almost every mining and ore-treatment purpose and have replaced the steam engine. The success achieved at Aspen led to the establishment of larger electric-power plants in connection with various other mines in Colorado, notably at the Virginius mine, Ouray County, the Silver Lake mine, near Silverton, etc.

The above-described conditions at Cripple Creek, therefore, naturally resulted in the establishment of two electric-power plants, viz., that of the Colorado Electric Power Company at Cañon City, nearly 30 miles south of Cripple Creek, and that of the La Bella Mill, Water, & Power Company at Goldfield in the Cripple Creek district itself. In each case, the electric power is produced from steam generated by the same quality of coal, from the same Cañon City coal field; the special difference between the two plants being that the Colorado Electric Power Company generates the power at the coalfield and transmits it 27 miles by wire to the gold mines, while the La Bella Mill, Water, & Power Co. (practically composed of the owners of the Florence & Cripple Creek Railroad) carries the coal to, and generates the electric power in, the gold-mining district itself, thus constituting a competi-

TWO VIEWS ON THE TRANSMISSION LINE FROM CAÑON CITY TO CRIPPLE CREEK.
The trail is cleared 30 ft. wide, to prevent trees falling on the line.

tion between modern electrical transmission and the older system of fuel transportation.

The Colorado Electric Power Co. (representing $500,000 of capital, mostly from Pittsburg, Pa.) completed its plant at Cañon City in

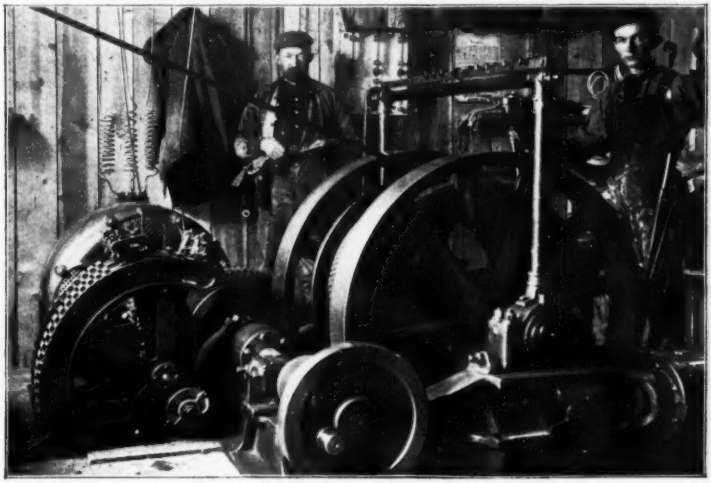


PLAN OF POWER HOUSE, COLORADO ELECTRIC POWER CO., CAÑON CITY.

August, 1898. It has a capacity of 2,250 h. p. The method pursued is to generate power at 500 volts, transform to 20,000 volts, and transmit at this voltage 27 miles to Cripple Creek. The transmission line consists of three No. 3 bare copper wires arranged in a triangle on 30-foot poles, one wire being at the top of the pole. The two wires of a

telephone circuit are also carried lower down on the same poles. At Cripple Creek there are two distributing stations, one on Gold Hill and the other on Battle Mountain, at which the current is transformed from 20,000 to 500 volts and distribution is made at the latter voltage.

The Colorado Electric Power Co. has already seventy consumers in the Cripple Creek district, representing an aggregate of about 1,200 h. p., the list comprising both mines and ore-treatment plants, by whom the power is utilized for hoisting, pumping, operating air compressors for drills, lighting, and, in the case of the ore-treatment plants, operating crushing and other machinery. Thus the Colorado



MOTOR RUNNING A HOIST FORMERLY OPERATED BY STEAM.
The plant is that of the Lafayette mine. The disconnected steam cylinder is seen on the right.

Ore Reduction Co. takes 150 h. p. for crushing machinery, etc.; the Lillie Gold Mining Co., 100 h. p. for hoist and air compressor; the Moon-Anchor Gold-Mining Co., 100 h. p. for pumping from a depth of 600 feet; the Taylor & Brunton Mill, 75 h. p. for crushing machinery, etc. The needs of the majority of the consumers range from 75 h. p. down to 5 h. p. A hoisting plant of 15 h. p. will suffice for a shaft 450 feet deep; when this depth is exceeded it is usual to put on 30 h. p., sufficient for 800 feet; for still greater depth 75 h. p. and 100 h. p. are installed.

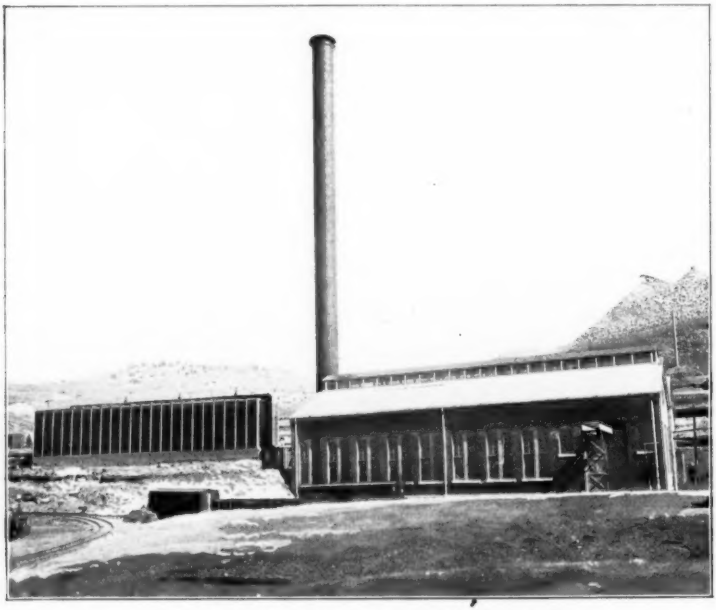
The company rents to a lessee or prospector a small hoist, say

from 5 h. p. to 30 h. p., thereby enabling such lessee or prospector to put practically the whole of his capital into development work, avoiding the necessity of purchasing a plant. If, however, he finds ore in paying quantities and desires to purchase the electric-power plant he has rented, the company in the first instance gives him an option on it, the rent applying on the purchase price.

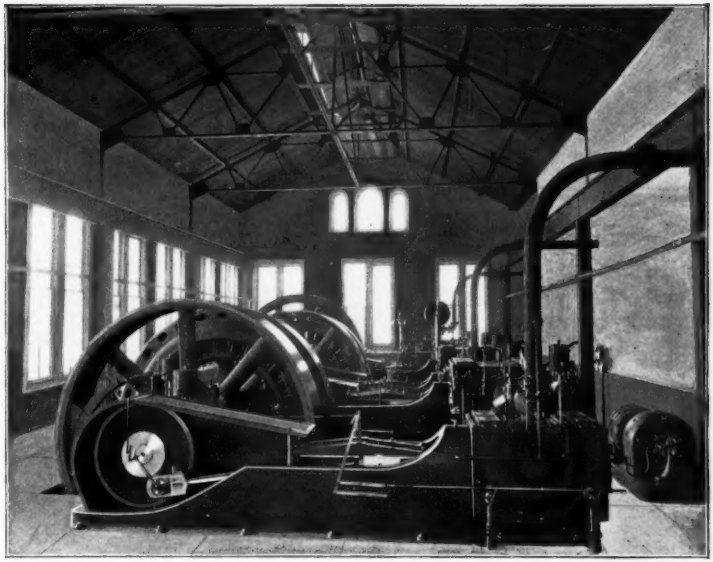
The minimum rent for a 5 h. p. plant is $50 per month, including rent and power supply; from that sum the charge ranges upwards according to the amount of power used. Plants from 15 h. p. to 30 h. p. range from $65 to $200 per month for rent of motor, etc., and power supply, depending on tonnage and depth of shaft.

The company has $60,000 worth of machinery so rented out and is preparing to extend its plant generally.

The following information as to the recently completed plant of the La Bella Mill, Water, & Power Co. at Goldfield has been furnished by Mr. L. L. Summers, of Chicago, who designed and superintended its construction and is now the consulting engineer. It has a capacity of 3,000 h. p., viz., 2,250 in electric power and 750 in com-



THE GOLDFIELD PLANT AND THE COOLING TOWER.



ENGINES, DYNAMO AND COMPRESSOR PLANT. LA BELLA MILL, WATER, AND POWER CO.

pressed air. It is one of the largest compressed-air distributing plants in the country, having ten miles of underground lines by which the air is distributed from the station to the various mines in the locality, including the Victor, Golden Cycle, Gold Knob, Granite, Rigi, Independence (of the Independence T. & M. Co.), Vindicator, Longfellow, Last Dollar, Union, Christmas, Jefferson, Ocean View, Anaconda, Ophelia Tunnel, etc. Some of these are as far as two miles from the station, while electrical power is transmitted five miles.

The loss in transmission of compressed air has received a great deal of attention by the engineers of the company and convenient tables have been prepared showing the loss by friction and by leakage.

As before mentioned, the capitalists composing this company are also practically the owners of the Florence & Cripple Creek Railway, and by this alliance the energy is distributed from the coalfield (by low fuel-freight rates) to the local power plant and thence to the mines, at a minimum rate.

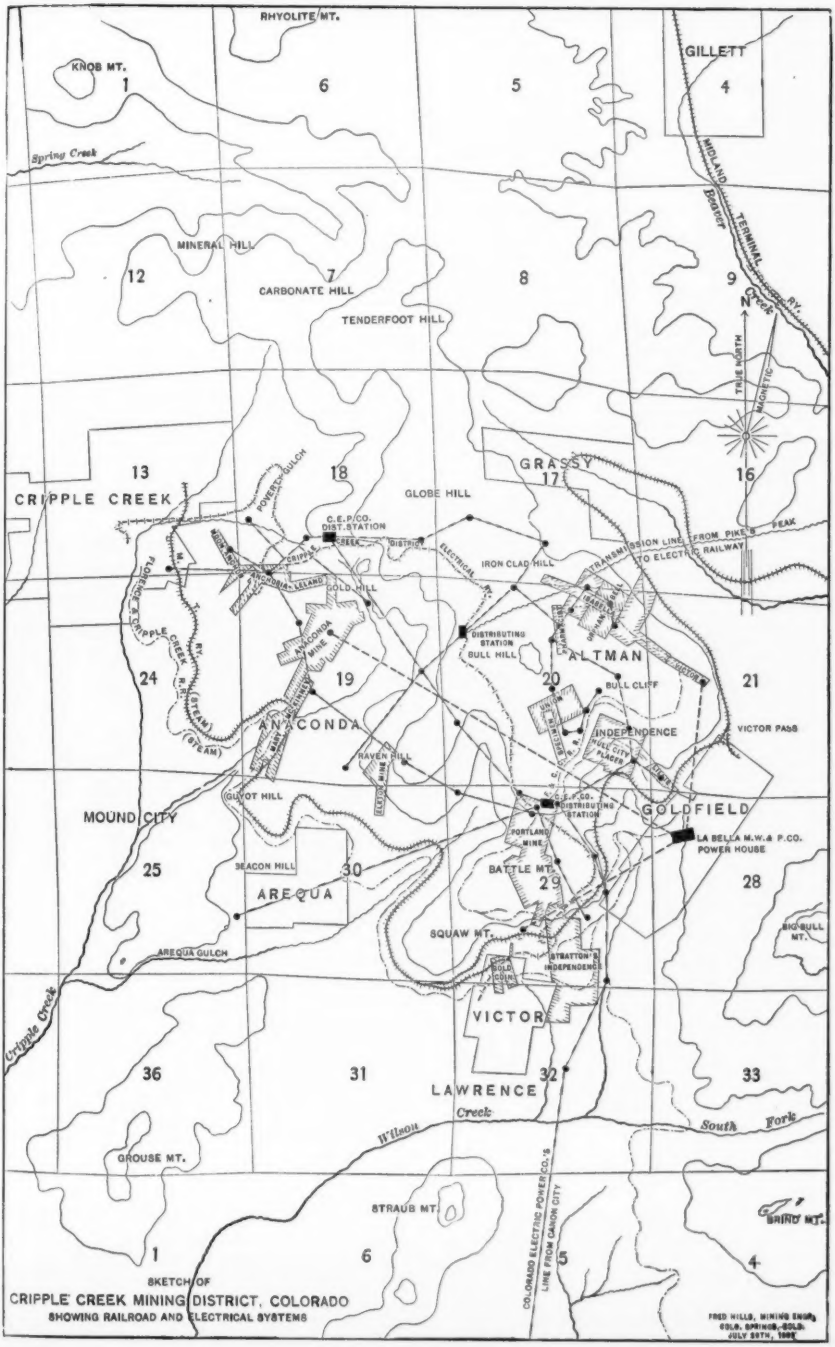
The plant is modern in design and equipment, the machinery being obtained from the works of the leading representative firms of the United States. The specifications are said to have been most exact-

ing with respect to efficiency and economy. Automatic machinery is used throughout, the coal being dumped directly from the cars into overhead bins, whence it is fed by gravity to automatic stokers, the ash being handled by conveyers and placed on board the railroad cars to be used for filling purposes. This automatic handling of the coal and ash reduces to a minimum the number of employees and materially keeps down the wage account. The boilers are of the water-tube type, 150 pounds of steam being carried, while the engines are of the compound condensing type with the most modern auxiliaries.

An interesting feature of this plant is the fact that condensing engines are used at a point 10,000 feet above sea level, where water is comparatively scarce in the absence of natural water courses, and the limited supply from springs more or less unreliable. In order that

BOILER ROOM OF THE GOLDFIELD ELECTRIC-POWER PLANT, SHOWING AUTOMATIC FEEDING AND STOKING APPARATUS.

condensing engines may be used under these circumstances, provision has been made to cool the water by means of cooling towers, when it is again used in the condenser. This is the first application of the cooling tower in Colorado, and the results in so large a plant are being watched with considerable interest. The elevation of 10,000 feet ne-


RHYOLITE MT.
KNOB MT.
GILLETT
Spring Creek
MIDLAND TERMINAL RY.
MINERAL HILL
CARBONATE HILL
TENDERFOOT HILL
TRUE NORTH
MAGNETIC
CRIPPLE CREEK
GRASSY
GLOBE HILL
POWERS GULCH
C.E.P.CO. DIST. STATION
TRANSMISSION LINE FROM PIKE'S PEAK
TO ELECTRIC RAILWAY
IRON CLAD HILL
GOLD HILL
DISTRIBUTING STATION
BULL HILL
ALTMAN
BULL CLIFF
VICTOR PASS
ANACONDA
INDEPENDENCE
RAVEN HILL
MOUND CITY
GOLDFIELD
LA BELLA M.W.& P.CO. POWER HOUSE
PORTLAND MINE
BEACON HILL
BATTLE MT.
AREQUA
SQUAW MT.
AREQUA GULCH
BIG BULL MT.
VICTOR
LAWRENCE
Creek
South Fork
GROUSE MT.
STRAUB MT.
COLORADO ELECTRIC POWER CO.'S LINE FROM CANON CITY
SKETCH OF
CRIPPLE CREEK MINING DISTRICT, COLORADO
SHOWING RAILROAD AND ELECTRICAL SYSTEMS

cessitated considerable change in the design and details of the condenser, owing to the fact that the barometer pressure at that elevation is only about twenty inches of mercury.

The electrical power is distributed by means of the triphase system. The voltage carried on the distributing lines is 6,600. The pressure being carried directly on the generator avoids the necessity for the use of step-up transformers. A transformer is placed at each mine and the voltage of 6,600 is reduced to 110 volts or 440 volts, depending upon whether lights or motors are being operated. By means of the pressure of 6,600 volts any portion of the district can be reached with comparatively small loss.

The company distributes considerable power in large units, one hoist motor operated from their lines being rated at 300 h. p., while 200-h. p. and 100-h. p. motors will be comparatively common, as well as smaller sizes. The loss between the power house and this 300-h. p. motor, a mile distant, is less than 2 per cent. In this way, the pressure on the service is maintained with comparative steadiness, in spite of the fact that large motors are operated under fluctuating loads.

The advantages of modern high-tension distribution are illustrated in this plant in a most pronounced way as evidenced by the small loss of energy, and lights can be operated from the motor circuits without disagreeable flickering or any indications of fluctuating loads on the circuit.

A great part of the lighting of the Cripple Creek district (including Goldfield, Independence, part of Anaconda, part of the town of Cripple Creek, in competition with older lighting plant, and Victor in the near future) is done from this plant. In the case of city and residence lighting the circuits are normally operated from the generator not carrying fluctuating loads.

Speaking generally, the principal uses of the electrical power furnished by the above-mentioned two plants are hoisting and air compressing for the operation of machine drills. Air compressing in the larger mines consumes about four times the amount of power required in any other service, for the reason that the compressor is operated almost continuously, while the hoist, though consuming a large amount of power when in use, is in active operation less than one-fourth of the time.

It is estimated that in the Cripple Creek district the use as above of electric power, as compared with steam power, effects a saving of from 15 to 50 per cent., according to the location and circumstances

of the mine, irrespective of reduced wage account, and also irrespective of its greater reliability and convenience, as unaffected by frost.

Drills of German manufacture, operated directly by electricity, without the invention of an air compressor, have for some time past been in successful operation in the Silver Lake mine, near Silverton, Colo., and it is evidently only a question of a short time when similar drills will be in use in the Cripple Creek district.

Electrical power is revolutionizing the mining industry at Cripple Creek in reducing expenses, increasing profits, and making available lower-grade ore, hitherto discarded or ignored as incapable of being mined and treated at a profit.

The whole movement is one of those, most characteristic of modern engineering work, in which an advance in any department extends its influence to, and re-energizes, other branches. The effect of the introduction of electric power is not only to cheapen production in mines already profitable, but to bring into working deposits which could not be mined to advantage under the older methods. The net result is a great increase of activity and labor-employment, and new openings for the utilization of capital, not only in the mining field, but in the manufacture of the electrical and mechanical appliances which have so greatly facilitated mining work.

AMERICAN LOCOMOTIVES ON BRITISH RAILWAYS.

By Charles Rous-Marten.

IT was naturally to be expected that a subject so highly controversial as that with which I have been dealing would elicit strongly divergent views, not merely as to the conclusions deducible from existent facts but also as to some points in those facts themselves.

Therefore it caused me no surprise to receive communications from British and American engineers remonstrating with me upon my "advocacy" of certain methods, and upon my statements as to certain American practices, it being pointed out in the latter connection that these practices are by no means universal. It was in vain that I said in the penultimate paragraph of my first article (THE ENGINEERING MAGAZINE, July, 1899: "I have endeavoured, as an entirely independent and impartial observer, to present a strictly fair view of the case. I have refrained from expressing any opinion as to the relative merits of the rival systems and their fruits. Nor do I pretend to assert that the general rules of practice to which I have referred have no exceptions. But I have treated the situation as it is found to exist in ordinary experience." But I ask permission to repeat those explicit assurances now in order that no excuse may remain for any misconception. I am endeavouring to outline in strictly general terms the salient differences in the views and methods that are to be found in Great Britain on the one hand and in the United States of America on the other. I say emphatically that in each case the practice which is the rule will usually be found to have its exceptions.

Before passing on I would like to correct one small misprint on Page 558 (July issue) viz., "brass upper tubes" should be, "brass *or copper* tubes."

Coming now to certain phases of my subject which are being keenly discussed in Great Britain, I may first refer to a letter from an eminent American engineer which is mainly a protest against what he terms "the curious idea prevailing in England that all American locomotives are built to a few standard designs and that the builders compel purchasers to accept these designs or go elsewhere." But after arguing that there are as many differences of design among American locomotives as among British—or, indeed, more—and that "American builders build locomotives to suit the purchasers"—which I

should have thought would "go without saying"—he adds: "The greatest facility which American builders possess arises in part from their stock of drawings and patterns which are available in new designs and for such parts of the engines as are not required to be made to special drawings. Thus one form of sand-box may be used on a multitude of engines, although a special form will be made to the purchaser's designs whenever required. The small railways, of course, which do not employ skilled mechanical engineers, leave much of the designing to the builders, and there is no reason why engines for the same class of work under similar conditions on two different railways should not be of practically identical design."

It will be seen at once that this entirely fits in with what I stated in general terms. Manifestly, there would be cases in which the chief mechanical engineer of an American railway would stipulate for engines to be constructed in detail, as well as generally, to his own design. But I am assured by representatives of American engineering firms that in the majority of cases the practice is virtually as I have described it. That is to say, instead of parts made by particular makers—A's x, B's y, and C's z—being compulsorily used as is often required by British specifications, many parts of each engine can either be supplied from materials in stock or be made from patterns, templates, etc., already in hand.

On the other hand, an English engineer writes to me: "It is not in the patterns or templates, but in the American practice of making spare finished parts for stock that the Americans have the advantage. If they can take these parts out of the shops they can begin erection at once. Hence the quick deliveries. I have seen it contradicted that this is the American practice and if the contradiction is true then the Yankees are no better off at all than English in the peculiar cases I have taken, and some other causes must be looked for." One of these he takes to be "the baneful restriction of output advocated by English trade unions" and another "the advantage of practice in putting together a few types of engines which the American is always accustomed to as against the infinite variety of type which the English erector has to put together, so that the latter expends half his time in consulting the drawings whereas the former gets so accustomed to these types that an old hand needs to look at the plans only now and then."

I make no apology for quoting these various comments because they tend to throw a good deal of "side light" on the question. It will be noticed by any acute observer, reading "between the lines,"

that practically it all comes round to the general principles which I endeavoured to set forth in my first article, viz., that in those cases in which the American builder has an advantage over the British builder—and, be it remembered, it is cases of this class with which I deal—that advantage is mainly due to the method of practice on which I have laid stress, namely, that it is not necessary for *every* part of the required engine to be absolutely created afresh, or at least to be produced *ab ovo*, there being, if not the entire skeleton, at least a good many bones at hand with which to begin the constructive or erective work.

In the present cases, for instance, the engines could be supplied in time to the Midland and Great Northern Railways only because each of those lines consented to accept the ordinary American type and merely stipulated for a certain specific power, *viz.*, that this should be equivalent to that of their own standard engines, except that in a few details, *e. g.*, in the materials used for tubes and fire-box, the British practice should be followed.

But there is another matter which should not be lost sight of in reviewing the whole situation, which it materially affects. Four of the most eminent British firms of locomotive builders have constructed for the Midland Railway a number of good engines of the present standard class and therefore must possess all the needful patterns, templates, etc. Clearly then, excepting for their not keeping in stock—so far as I am aware—a supply of spare finished parts, they stood on equal terms with the American builders in tendering. The disadvantage under which they laboured was the plethora of orders. This necessarily put them "out of court" because it incapacitated them from fulfilling one of the essential conditions—that of time. Otherwise they could probably have executed the order with as much despatch as the Americans—or nearly so. But, practically, the order as it stood—that is to say, to deliver the engines within a given time—could not be undertaken at all. And I believe a question of price also arose, but this is not disclosed.

Thus, then, we arrive at a new position of large interest on both sides of the Atlantic. It was expressed very pointedly a few days ago by Mr. H. A. Ivatt, the able locomotive superintendent of the Great Northern Railway, during a conversation with reference to the orders given by English railways for American locomotives. "It means," he said, "that henceforward American builders will be in the field as competitors with British builders for the supply of such engines as the British companies themselves cannot build." Clearly that is so. It is

virtually proved that, in certain cases at any rate, American builders can supply locomotives much more quickly and somewhat more cheaply than British makers hitherto have done. If experience should further prove that the American-built locomotives are for all practical purposes as good as the British-built engines, the sequel seems inevitable. It is certainly to be expected that, in that case, the British railway companies will prefer the makers who supply an equally useful engine and do so more speedily and cheaply. Obviously, then, the present situation is one of absorbing interest for both American and British engine-builders.

One question which arises in this connection I must leave for other hands to deal with. It is as to how far the American builders may be facilitated and assisted in their present and future competition with British firms by their possession of superior appliances. The idea naturally suggests itself on noting that the various machines in the Baldwin shops are actuated by independent electric motors. At the first glance I should deem this an improvement upon the usual British practice and one tending to enhanced speed and facility of working. I prefer, however, to relinquish the discussion of that phase of the case to someone who can speak from closer personal knowledge in detail of the method. But whatever may be the true explanation, the definite fact remains that there does appear to be a distinct American superiority in respect of feasible rapidity and economy of construction.

A few days ago I visited Derby by invitation for the purpose of examining the engines constructed at the Baldwin works for the Midland company, of which a number had been placed on some short sidings outside the works and were in course of erection by the representative of Messrs. Burnham, Williams & Co. and his assistants. Much difficulty has been experienced in obtaining a sufficient supply of skilled labour, owing to the large demand for it at the present time; the Midland company is bound only to provide unskilled labour for the erection. Consequently the progress has been slow and so far only one of the engines has been tried in steam. Unfortunately, this pioneer was immediately disabled by a slight accidental collision and has had to go in for repairs. Therefore so far not a particle of information can be given as to results. I may say that I was very favourably impressed with the appearance of the engines which, except for the domed sand-box above the boiler, had little of the unfamiliarity of aspect to British eyes that would have been given by a "diamond" smoke-stack, huge head-light, and "cowcatcher." Even the

double-bogie tender is no longer a stranger to Great Britain, although in British practice it is not deemed necessary to place on eight wheels so comparatively small a tender as that attached to these engines. Upon making a more minute examination, I could not help noticing the rougher external condition of some of the castings as compared with those in the Derby-built engines, in the parts where extreme finish was not required for practical purposes. But I could not see that the engines suffered any loss of usefulness through the external roughness of such a part as, for instance, the valve-chest, which, moreover, was not exposed to view owing to its casing.

Mr. S. W. Johnson, the eminent mechanical engineer-in-chief of the Midland line, who courteously accompanied me on my inspection, appeared to concur in this view, although he declared very explicitly his determination not to form or express any opinion upon the merits of the engines until these should have been ascertained by actual trial. He informed me that so soon as all the American engines should be erected they would be placed on regular duty in comparison with a like number of British-built engines of approximately equal power and, after a lengthened period of test, the results would be fairly and impartially compared. But Mr. Johnson conveyed to me the impression that so far he was disposed to regard the American engines very favourably as likely to fulfil satisfactorily the stipulated requirements and to do good work. Nor did he seem to think that their longevity need necessarily be less than that of the British engines. When I remarked on the absence of the fluted connecting-rod and side-rods which have become so common in American practice and, indeed, in British practice also, Mr. Johnson explained that personally he preferred plain rods as giving more elasticity in rounding curves, the fluted rods being, in his opinion, although doubtless stronger, yet too rigid and unyielding, while on the other hand he did not find the plain rods, although more elastic, addicted to bending or breaking. For the rest, Mr. Johnson held that the result of the new experiment could only be learned as the outcome of protracted experience and he prudently declined to commit himself to any judgment whatever at the present stage. The engines had been obtained from America, he said frankly, because the company needed them urgently and could not procure them soon enough from any British makers. That was the whole story; its moral is in the womb of the future.

I am indebted to Mr. Johnson for the accompanying tabular statement which he was good enough to draw up, showing in what dimensional respects the American engines built at the Baldwin and

MIDLAND, BALDWIN, AND SCHENECTADY GOODS ENGINES.	MIDLAND.	BALDWIN.	SCHENECTADY.
Diameter and stroke of cylinders	18″ x 26″	18″ x 24″	18″ x 24″
" of driving wheels	5′ 2½″	5′ 0″	5′ 0″
" of pony "	.....	2′ 9″	3′ 0″
Centre of boiler from rails	7′ 2″	7′ 2″	7′ 0⅝″ about.
Pressure per square inch	160 lbs.	160 lbs.	160 lbs.
Grate surface	17.5 sq. ft.	16.7 sq. ft.	16 sq. ft.
Length of firebox, outside	5′ 11″	6′ 9⅛″	6′ 9⅛″
Heating surface, firebox	110 sq. ft.	120 sq. ft.	122 2 sq. ft.
" " tubes	1,141 sq. ft.	1,244.6 sq. ft.	1.092.7 sq. ft.
" " total	1,251 sq. ft.	1,364.6 sq. ft.	1,214.9 sq. ft.
Number of tubes	244	263	219
Diameter of "	1⅝″	1¾″	1¾″
Length over plates	11′ 0⅛″	10′ 5¾″	11′ 0″
Tender capacity	3,250 gals.	3,250 gals.	3,250 gals.
" wheels, diameter	4′ 2½″	3″ 0″ bogie.	4′ 2½″
Wheel base, engine and over pony	16′ 6″	14′ 9″ and 22′ 2″	15′ 6″ and 23′ 0″
" " tender and centres of bogies	11′ 0″	14′ 4″ and 9′ 8″ centres each 4′ 8′	12′ 3″
" " extreme	37′ 8¼″	43′ 0″	43′ 0″
Length over buffers	49′ 8½″	52′ 1″	
	tons, cwt., qrs	tons, cwt., qrs.	
Weight of engine, working order, pony	None.	7 12 3	
" " " " leading	13 8 3	11 8 0	
" " " " driving	14 11 0	13 9 1	
" " " " trailing	11 9 2	13 15 2	
" " " " total	39 9 1	46 5 2	
Weight of tender	37 0 0	32 17 3	
" engine and tender, working order	76 9 1	79 3 1	
" " " empty	36 1 0	41 4 5	
" tender, empty	18 19 2	16 8 0	
" engine and tender, empty	55 0 2	57 12 3	
Tractive power in lbs. and tons, at 160 lbs boiler pressure	16,174 lbs. = 7.22 tons.	15,552 lbs. = 6.94 tons.	15,552 lbs. = 6.94 tons.

TABLE SHOWING DIMENSIONS OF AMERICAN AND ENGLISH LOCOMOTIVES FOR SIMILAR SERVICE ON THE MIDLAND RAILWAY.

Schenectady works respectively, for the Midland Railway, compare with and differ from the standard goods-engines designed by him and constructed at the Midland works, Derby. It will be observed that, while all three classes of engines have 160 lbs. steam pressure—the published statement that the Baldwin engines had 180 lbs. being erroneous—the Baldwin engines have 113 sq. ft. more heating surface than the Derby engines, but the Schenectady have 36 sq. ft. less than the Derby type. Both American classes have larger fireboxes and grate area than the British, but the Baldwin has more, and the Schenectady less, tube surface. Further, the Baldwin engine weighs about seven tons more than the Derby one; but the Baldwin tender, although it has an extra pair of wheels, is about four tons lighter than the Derby tender. Finally, comparing the tractive power exercisable by each engine, that of the Baldwin is 0.961 to the Derby's 1.000, and consequently that of the Derby locomotive is 1.041 to the Baldwin's 1.000. It remains to be seen how far these relative theoretical capacities will be verified by the experiences of actual practice, and how far the additional fire-box and fire-grate area of the Midland engine compensate for the comparative deficiency in nominal power.

At Doncaster I found Mr. H. A. Ivatt, the chief mechanical engineer of the Great Northern Railway, equally reticent as to his opinion upon the relative merits of the American and British methods. He mentioned that, in the engines under construction in the United States for the Great Northern main line, he had caused the sand-box to be placed below the frame instead of being on the top of the boiler as is usual in American practice. This will remove another of the differences in outside appearance and, with the domed sand-box, diamond smoke-stack, big head-light and cowcatcher all gone, there will be little to strike the casual but prejudiced eye of the average Briton as prominently non-British. This is a more important point than it may seem at first sight to be, for railway directors do not like to offend the prejudices of their customers, the British public, by any needlessly obtrusive display of "foreignism" about their locomotives or rolling stock. Thus if the American-built engines can be turned out so similar in outside aspect to the British-built article that only the eye of an expert can detect the difference off-hand, and if these engines can be supplied more promptly and more cheaply than the home product, it needs little of the spirit of prophecy to foresee that keen American competition in locomotive supply is one of the conditions with which British engineering firms will have to reckon very seriously in the near future.

Even on the point of durableness it appears by no means certain that the American product will manifest any shortcoming. "Why should they not last well?" said Mr. Ivatt, during our recent conversation. "I have been examining them and I cannot find any important part that ought not, with fair usage, to last as long, or nearly so, as those of our own engines." He added that, although the work was not so highly finished in some cases as that of an English-built engine, there was nothing in this lack of external finish that militated in any degree against the efficacy of the locomotive.

Both Mr. Johnson and Mr. Ivatt appear determined to give the American engines a thoroughly fair trial and test in every possible respect. The Americans will work, turn for turn, with British-built engines and will have every chance of showing what they can do in varying circumstances and under varying conditions. If they come out of this ordeal triumphant, then the American builders and American methods will have scored heavily and will have established a strong footing in this ultra-conservative country. And in my opinion, should that favourable result be attained, the outcome will be to place American engineering firms at least on an equal footing with British when any new engines have to be tendered for. That is to say, they will be offered an equal opportunity of competing. The mere distance and separation by ocean go for very little. All that resolves itself into a simple question of freightage. From my own experience of American engines in the British colonies, I entertain no doubt of their proving entirely satisfactory in the mother country. I anticipate that they will be found peculiarly easy on the permanent way, owing to the good services of the faithful "track-feeler," the pony-truck. A veteran British engineer, Mr. David Joy, the inventor of the famous valve-gear which bears his name, was conversing with me to-day on the subject, and he expressed that opinion very strongly, but he doubted whether the American locomotives might not be "heavier on repairs" than the British. This, however, has yet to be seen.

Regarding the whole question from a purely impartial and scientific standpoint, I cannot help feeling personally much gratification that the occasion should have at last arisen for a comparative and competitive trial of British and American methods. And I wish very much that an opportunity might offer of a similar comparison between passenger engines or express engines designed and built in the two countries. For while I do not believe that any locomotives in the world will be found to beat the British engine *in respect of performance per unit of nominal power*—power of boiler and fire-box, I mean,

as well as of cylinders and wheels—I am nevertheless convinced, again from my own colonial experience, that the American engines would hold their own very effectually and would perhaps teach us a few things which are often ignored or overlooked, but which it would be clearly to our advantage to have more forcibly impressed upon our notice.

There is no reason why the differences of practice should stand in the way. These are by no means of vital import. Some of the American peculiarities are purely superficial. Others appear to be unquestionable improvements, including the larger boilers and fireboxes, steam-ports, and exhaust-ports. As to several there is diversity of opinion, among these being the bar framing, the equalising-levers between the springs, the outside cylinders, the valve-gear arrangement, the cast-iron wheel-centres, and the steel tubes and fireboxes.

Some of these have already been adopted occasionally in British practice. As to the use of steel for fireboxes which has always been a matter of keen controversy, while British experience has gone entirely in favour of copper—although I believe that the Great Eastern has tried steel with some success—there is much to be said on behalf of the American method. It is contended that by the use of a single metal difference in expansion is avoided, whereas, if copper and steel be used respectively for the inside and outside boxes, they expand differently with disadvantage to the structure. Another argument employed in favour of steel is that galvanic action is not set up, as is the case when two metals such as copper and steel are used, with resultant corrosion of the plates. Further, American engineers hold that the heat of the fire is transmitted more readily to the water in the boiler through thin steel plates than through copper. Moreover, the greater facility with which thin steel plates yield between the stays without undergoing rupture when different degrees of expansion occur, is held to be in their favour. On the other hand, it is undeniable that hitherto the experience in Great Britain with steel fireboxes has not, as a rule, resulted satisfactorily. The question is clearly a moot one.

None of these points, however, present, any impediment to the trial in England of express engines constructed on the American system. And such experiments would indisputedly be of the highest interest, while the outcome could hardly fail to be a valuable addition to our existing knowledge and experience in connection with the important science of locomotive-engineering.

MECHANICAL USES OF THE SCIENCE OF METALLOGRAPHY.

By Albert Sauveur.

THE physical properties of metals and of metallic alloys, to which these metallurgical products owe their great industrial importance, do not depend exclusively upon their chemical composition. They depend also, to a very great extent, upon the treatments, thermal and mechanical, to which the metals have been subjected, and if different treatments impart different properties to a metal whose composition remains unchanged, it is because such treatments modify its structure. It is therefore of as great importance to study the structure of metals, as it is to determine their ultimate compositions. The physical properties of a metal are a function of its chemical composition and of its structure, and the importance of the second factor is as great as that of the first.

While chemical analysis informs us with great nicety of the ultimate composition of metals, it throws no light upon the character of the treatment to which they have been submitted. A piece of steel, for instance, may receive a thousand different treatments and its ultimate composition remain unaltered throughout, although such treatments modify its mechanical properties. It is precisely here, where chemistry fails us, that the usefulness of the microscope asserts itself, for the microstructure of metals is extremely sensitive to slight changes of treatment. The character of the treatment is always unmistakably written in the structure; it only remains for us to learn how to read and interpret these structural changes, and to this end our efforts should bend.

The study of the structure of metals has been actively pursued for the last ten or fifteen years, in all metallurgical countries, and has called into existence a new department of metallurgy, for it has been shown that all alloys and all industrial metals (which always contain a certain amount of impurities), are made up of constituents which may be regarded as minerals, and as the study of rocks created the science of petrography, from the study of the constitution of metals was developed the new science of "Metallography."

Metallography, then, might be defined as being the science of metals with special reference to their structure.

PREPARATION OF THE SAMPLES.

Size and Shape of Samples.—Samples of metals to be examined under the microscope should not be less than ⅛ in. thick, whenever practicable, and the surface to be polished should measure from ¼ to 1 inch in diameter or in side dimensions. Circular and square, or nearly square, pieces are preferable. Specimens considerably smaller or larger, however, may be handled under the microscope without much inconvenience.

If the metal is too hard to be machined, as is the case with white cast iron, spiegeleisen, ferro-manganese, hardened carbon steel, very high carbon steel and some of the so-called steel alloys, such as manganese steel, a piece of a convenient size must be broken off with a cold chisel and sledge hammer.

The surface to be examined is ground flat on an emery wheel or filed with suitable files.

Grinding and Polishing.—The purpose of this operation is to produce a surface free from scratches and from any markings which do not belong to the structure of the metal. If this has been successfully done, the metallic surface should appear highly specular. With that end in view the sample is ground very gradually by means of abrasive material of increasing fineness; the minute markings left by the last grinding being finally removed by a polishing powder. Emery is the grinding substance which naturally suggests itself. Starting with a grade sufficiently coarse to remove promptly the file marks, the specimen is rubbed in succession over two or three finer grades. The markings left by the last grinding should be sufficiently light to be speedily removed by the polishing powder. The emery may be used in the shape of emery wheels of various grades, or of emery papers, or emery cloths, or else the powder itself may be spread loose upon a suitable foundation. In the last treatment with the emery, flour emery, used wet upon a cotton cloth stretched tightly over a block of wood, will be found very effective. Jewelers' rouge of the best quality, spread upon a piece of chamois skin stretched over a piece of wood or marble, is the polishing powder universally used for the final polishing; it should be used wet. When passing from one powder to the next, it is best to rub the specimen at right angles to the marking left by the previous operation, as it can then be ascertained more readily when these have been completely removed.

The scratches left by the finest grade of emery are sometimes effaced only with great difficulty by the polishing rouge. To facilitate the work various powders, such as crocus, water-of-Ayr stone,

crushed oil stone, *brillant belge,* etc., have been used between the last emery grinding and the final polishing. The writer, however, finds tripoli powder more effective for the purpose than any of the others; it should be used wet upon a cotton cloth.

When the final polishing is conducted on a piece of soft chamois leather, with plenty of water, the various constituents, if they vary much in hardness, are not worn to exactly the same level, the harder ones standing somewhat in relief. The structure of certain samples may thus be partially revealed without further treatment, and this relief effect may be intensified by using a soft, yielding support, such as a piece of parchment stretched over a block of soft wood. thoroughly soaked and covered with very little rouge. It is, however, nearly always necessary to develop the structure of the polished surface by further treatment.

Development of the Polished Surface.—There are several methods of developing the structure, *i. e.,* of imparting to the various structural components unlike appearances, so as to make them distinguishable under the microscope.

The method most commonly used consists in etching the specimen with some suitable reagent, such as the various mineral acids, certain salts, caustic potash, ammonia, tincture of iodine, etc.

In the case of iron and steel, nitric acid, varying in strength from 1 part acid in 50 parts of water to 1 part acid in 1,000 parts of water, and tincture of iodine, yield the best results. In etching with acid, the specimen is immersed in the bath for ten or twenty seconds, carefully wiped and examined under the microscope. If it is not sufficiently etched the treatment is repeated. In etching with tincture of iodine a few drops of the reagent are poured over the polished surface and allowed to act until the liquid is quite discolored. The sample is then washed in alcohol and dried, the treatment being repeated if required. A method which the writer finds to yield very satisfactory results in the case of certain grades of iron and steel consists in dipping the specimen in strong nitric acid (1.42 specific gravity), which in this degree of concentration has no action on the polished surface. The specimen is then held under an abundant stream of running water and the acid quickly washed off. As soon as the layer of concentrated acid which covers the surface is diluted by the running water it attacks the steel vigorously, but for such a short time (since the water soon removes all trace of acid) that there is no danger of etching too deeply. One such treatment is generally sufficient to bring out the structure sharp and clear.

Metallic alloys are generally etched while being subjected to electrolytic action. The sample, resting upon a platinum plate, is immersed in a suitable saline solution, or in dilute sulphuric acid (1 part acid to 10 parts of water is recommended by Guillemin); the platinum plate is connected with the positive pole of an electric current, while another piece of platinum placed in the solution is connected with the negative pole. If the vessel holding the etching fluid be made of platinum, and the samples to be etched be in contact with it, the vessel itself may be connected with the positive pole. A single Daniell cell furnishes a current of suitable strength.

The structure of some metallic alloys may be brought out very satisfactorily by etching them with dilute nitric acid, caustic potash or ammonia, or even by exposing the polished surface to the action of sulphuretted hydrogen. The best treatment to follow depends, of course, upon the nature of the alloy. The preparation should be washed with alcohol after coming out of the etching bath.

The structure of a polished metallic surface may also be brought out, sometimes very successfully, by heating it gently and gradually in contact with the atmosphere, by holding the sample over a Bunsen flame for instance. The different constituents assume, in rapid succession, but with varying velocities, different shades due to the formation of light films of oxides, in such a way that at no instant of the heating are two components colored alike, the harder constituent, in the case of steel, keeping in advance of the softer one. This method, however, is somewhat uncertain and not of general application.

THE STRUCTURE OF PURE METALS.

All pure metals crystallize upon solidifying into irregular polyhedric crystalline grains. A polished and etched section will, therefore, exhibit a network structure, the fine network indicating the junction lines between the grains, Fig. 1. The dimensions of the grains vary with the temperature from which the metal is allowed to cool and with the rate of cooling; generally speaking, the higher the temperature and the slower the cooling, the larger the grains.

When the metal is associated with a minute quantity of another metal, the foreign element appears to unite with a small amount of the main mass and upon solidification forms a membrane which cements together the grains of the pure metal, Fig. 2. Both illustrations are from drawings by Andrews. It has not yet been conclusively shown that the cementing material is the true eutectic alloy of the two metals, to be described later, but it is quite natural to suppose such to be the case.

THE STRUCTURE OF METALLIC ALLOYS.

Alloys Made Up of Two Component Metals.—The modern theory of binary alloys, so brilliantly worked out, notably by Dr. Guthrie, H. Le Chatelier, Heycock and Neville, Sir William Roberts-Austen, Charpy and Gautier, classifies all such mixtures into three classes:

I. Alloys whose component metals form neither definite chemical compounds nor isomorphous mixtures.

II. Alloys whose component metals form definite chemical compounds.

III. Alloys whose component metals form isomorphous mixtures.

When an alloy of the first group is allowed to cool from the molten state, it gives rises, on solidifying, to the formation of a structural constituent of *constant composition* whatever the proportions of the

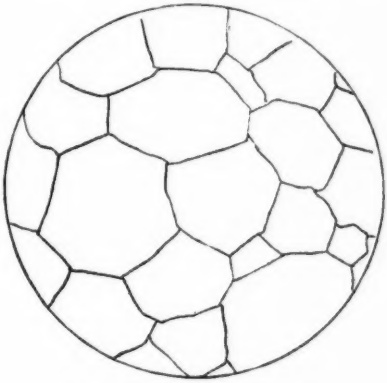


FIG. 1. PURE GOLD, MAGNIFIED 100 DIAMETERS.

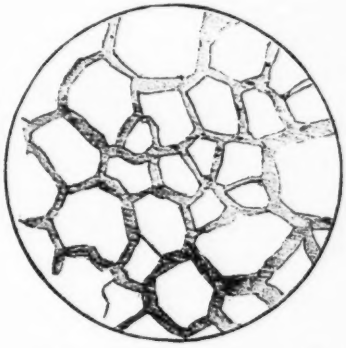


FIG. 2. GOLD WITH 0.20 PER CENT. OF LEAD. MAGNIFIED 100 DIAMETERS.

two metals in the alloy. It is called the *eutectic* alloy, a name proposed for it by Dr. Guthrie. Unless the alloy, therefore, has exactly the composition of the eutectic mixture, it contains an excess of one or the other metal. On allowing the molten alloy to cool, when a certain temperature is reached, which temperature *depends upon the composition of the mass,* the metal in excess begins to crystallize and continues to do so on further fall of the temperature, until the remaining portion of the liquid, which becomes all the while poorer in the metal present in excess, has reached the composition of the eutectic alloy. At that instant the temperature ceases to fall, and the remaining liquid, *i. e.*, the eutectic alloy, solidifies as a whole and at a *constant temperature.* The

solidification of the eutectic alloy always takes place at the same temperature, whatever the composition of the alloy. Its freezing point is also the lowest possible in each series of alloys. Eutectic alloys, therefore, at once recall the cryohydrates of saline solutions.

Eutectic alloys are not definite chemical compounds; they result from the simultaneous solidification of both metals present. The microscope has shown that they are made up of extremely minute crystals or plates, alternately of one and the other component.

On account of the minuteness of their constituents, eutectic mixtures often require very high magnifying powers for their resolution, and they frequently present under the microscope bright interference colors, recalling the appearance of mother-of-pearl.

Alloys of the first group, therefore, will be composed of crystalline particles of one of the component metals (the one present in excess), surrounded by the eutectic alloy.

As an illustration of mixtures of this character, the structure of three alloys of silver and copper is shown in Figs. 3, 4 and 5, taken from photo-micrographs by Osmond. The eutectic alloy of silver and copper contains 28 per cent. of copper and 72 per cent. of silver, and its structure is shown in Fig. 3 under a magnification of 600 diameters. It is made up of thin plates of irregular grains alternately of silver and copper. Fig. 4 exibits the structure of an alloy containing a large excess of silver (85 per cent. silver) with regard to the composition of the eutectic alloy. It is composed of large rounded grains of pure silver surrounded by the eutectic alloy. The structure was made apparent by heating the preparation to a purple color, which accounts for the dark appearance of the silver. In Fig. 5 we see the structure of an alloy containing an excess of copper (65 per cent. copper); it is composed of large areas of copper, surrounded by some eutectic alloy whose characteristic structure is sharply defined.

In Fig. 6, reproduced from a photo-micrograph by Charpy, is shown another typical instance of the peculiar constitution of eutectic alloys. It represents an alloy of silver and antimony containing 66 per cent. of silver, *i. e.*, an excess of that component corresponding to the white areas in the illustration.

In order to understand more readily the formation of the structure of alloys of the second group, *i. e.*, whose component metals form some definite chemical compounds, let us consider an individual case—that of antimony and copper alloys.

Copper and antimony form a definite compound answering to the formula $SbCu_3$ and containing about 60 per cent. of copper. If the

FIG. 3 ALLOY OF SILVER AND COPPER.
Copper, 28 per cent.; silver, 72 per cent.
Magnified 600 diameters

FIG. 4. ALLOY OF SILVER AND COPPER.
Copper 15 per cent ; silver, 85 per cent.
Magnified 600 diameters.

FIG. 5. ALLOY OF SILVER AND COPPER.
Copper, 65 per cent ; silver, 35 per cent.
Magnified 600 diameters.

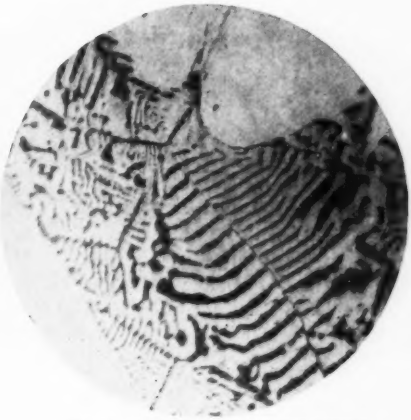


FIG. 6. ALLOY OF SILVER AND COPPER.
Copper, 66 per cent.; antimony, 34 per cent.
Magnified 500 diameters.

MICROPHOTOGRAPHS SHOWING THE STRUCTURE OF ALLOYS OF SILVER WITH COPPER AND ANTIMONY.

alloy contains less than 60 per cent. of copper it should be considered not as an alloy of antimony and copper, but as one of antimony and the definite compound $SbCu_2$. It will then be found that upon solidification such an alloy gives rise to the formation of an eutectic mixture made up of antimony (75 per cent.) and the definite compound. If, on the contrary, the alloy contains more than 60 per cent. of copper, it should be regarded as an alloy of copper and the compound $SbCu_3$, and the formation of its structure will then be found to follow the laws which have been seen at work in the case of the first group. When a certain temperature is reached the portion remaining liquid will solidify as a whole and at a constant temperature, which corresponds to the solidification of an eutectic alloy (containing 71 per cent. of copper) made up by the close juxtaposition of particles or plates of copper and of the definite compound.

Alloys of copper and antimony, then, containing less than 25 per cent. of copper (the amount found in the first eutectic mixture) will be made up of particles of pure antimony embedded in a matrix of an eutectic alloy made up of antimony and the compound $SbCu_3$; alloys containing between 25 and 60 per cent. of copper (the percentage present in the definite compound) will be composed of particles of the definite compound in a matrix of the same eutectic alloy; alloys containing from 60 to 71 per cent. of copper (the proportion found in the second eutectic mixture) will be made up of particles of the definite compound embedded in a matrix of an eutectic alloy made up of copper and the compound $SbCu_3$; finally if the alloy contains more than 71 per cent. of copper it will be composed of particles of pure copper, in a matrix of the same eutectic mixture.

The above variations of the structure of alloys of copper and antimony are well illustrated in Figs. 7, 8, 9 and 10, reproduced from photo-micrographs by Charpy.

The alloy represented in Fig. 7 contains 10 per cent. of copper. The white portions represent crystals of antimony, the black background the first eutectic mixture. A higher magnification is required to resolve the structure of the latter. Fig. 8 shows the structure of an alloy containing 40 per cent. of copper; it is composed of violet-colored crystallites of the definite compound, surrounded by the first eutectic mixture, shown in black in the photograph. Fig. 9 exhibits the structure of an alloy containing 65 per cent. of copper; it is made up of large violet-colored crystalline grains of the definite compound surrounded by a network of the second eutectic alloy. Finally Fig. 10 illustrates the structure of an alloy containing 85 per cent. of copper;

FIG. 7 ALLOY OF COPPER AND ANTIMONY, 10 PER CENT. COPPER.
Magnified 60 diameters.

FIG. 8. ALLOY OF COPPER AND ANTIMONY, 40 PER CENT. COPPER.
Magnified 60 diameters.

FIG. 9. ALLOY OF COPPER AND ANTIMONY.
Copper, 65 per cent.; antimony, 35 per cent.
Magnified 100 diameters.

FIG. 10. ALLOY OF COPPER AND ANTIMONY.
Copper, 85 per cent.; antimony, 15 per cent.
Magnified 30 diameters.

MICROPHOTOGRAPHS SHOWING THE STRUCTURE OF ALLOYS OF COPPER AND ANTIMONY.

FIG. 11.

Alloy containing 21 per cent. of lead, 5 per cent. of tin, and 74 per cent. of bismuth, showing the three successive stages of the solidification.

it is composed, in nearly equal proportions, of pure copper (the light areas in the photograph) and of particles of the second eutectic mixtures.

To sum up, metallic alloys whose component metals forms a definite compound are made up of only two structural constituents, one of them being one of the pure metals or the definite compound, according to the composition of the alloy, the other an eutectic alloy of one of the metals with the definite compound.

A small number of alloys belong to the third group, *i. e.*, their component metals form isomorphous mixtures. Upon solidifying they always form the same kind of crystals, whatever the relative proportions of the metals. The composition moreover may, according to Charpy, vary in the same crystal. The properties of such alloys have no critical point; they vary continuously and uniformly with the composition.

Alloys Made of Three Component Metals.—Until quite recently the structure of binary alloys only had been studied systematically, but M. Charpy, in some recent investigations, has examined the structure of a series of alloys made up of three constituents, mostly bearing alloys, applying to their study the methods which had been used with so much success in the case of binary alloys.

M. Charpy found a number of ternary alloys whose com-

FIG. 12. STEEL OF MEDIUM HARDNESS, SLOWLY COOLED.

The membrane of ferrite is seen enveloping grains of pearlite.

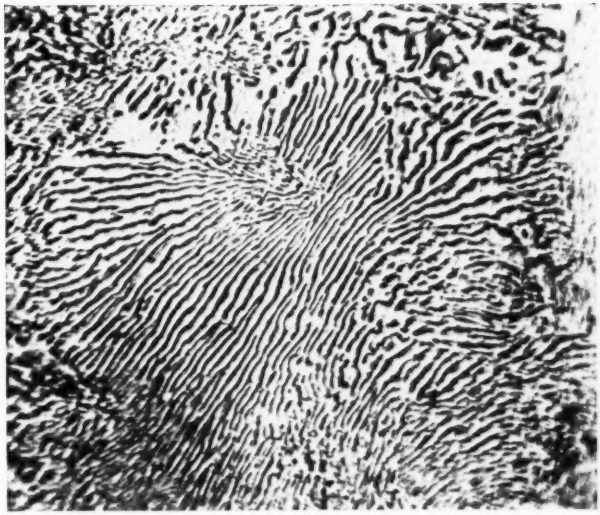


FIG. 14. STEEL, 1 PER CENT CARBON. MAGNIFIED 1,000 DIAMETERS.

FIG. 15. STEEL, 1.5 PER CENT. CARBON. MAGNIFIED 1,000 DIAMETERS.

FIG. 16. HARDENED STEEL, 0.45 PER CENT. CARBON. Magnified 1 000 diameters.

ponent metals form neither definite chemical compounds nor isomorphous mixtures, similar therefore to the first group of binary alloys, and he further found that the formation of their structure also follows analogous laws. This is well illustrated in alloys of lead, tin, and bismuth. If such a alloy be allowed to cool from the molten state, when a certain temperature is reached which varies with the composition of the alloy, the metal present in the greatest amount begins to solidify and continues to do so until a certain lower temperature is attained, when an eutectic mixture made up of that constituent and of one of the other component metals begins in turn to solidify, its solidification continuing on further cooling until finally, at a temperature which this time is independent of the composition of the alloy, the composition of the remaining portion of the liquid has reached the composition of the true eutectic alloy of the tenary alloy, which then solidifies as a whole and at a constant temperature. Like the eutectic mixture of binary alloys, the eutectic mixtures of tenary alloys are made up of extremely minute particles or plates of the *three* components in close juxtaposition.

Fig. 11 illustrates the micro-structure of an alloy containing 74 per cent. of bismuth, 21 per cent. of lead and 5 per cent. of tin. The three constituents described above are easily discernible. The white structureless areas correspond to particles of pure bismuth which solidified first. They are surrounded by an eutectic mixture made up of small particles alternately of bismuth and tin, which in turn is embedded in a matrix of the true eutectic alloy, which under a high magnification is found to be composed of minute grains of bismuth, tin and lead.

M. Charpy has demonstrated the importance of the mierographic test applied to the bearing metals. He has shown conclusively that such alloys should be made up of hard grains embedded in a plastic

matrix, and it is only with the assistance of the microscope that it can be ascertained whether they possess the required structure.

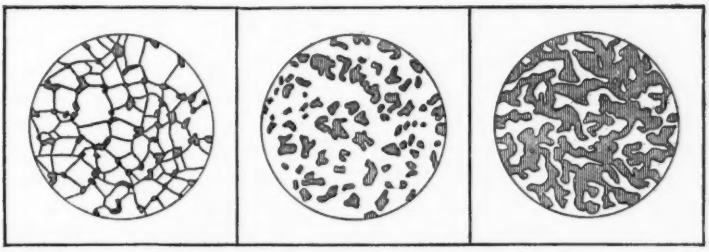
THE STRUCTURE OF IRON AND STEEL.

Pure Iron.—Like all pure metals, carbonless iron is made up of irregular, polyhedric, crystalline grains, which vary in size and shape with the treatment to which the metal has been subjected.

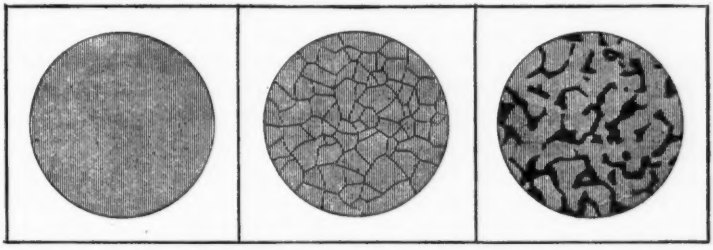
Unhardened Steel.—Steel in its unhardened condition is made up of three microscopical constituents, only two of them however being ever present in the same sample.

I. *Ferrite.*—This is iron free from carbon. It constitutes, of course, the totality of carbonless iron and decreases in amount as the percentage of carbon in the steel increases. With a carbon-content of about 0.80 per cent. there is no ferrite in the steel (see Plate 1).

When present in considerable quantity, as in iron and soft steel, it segregates in relatively large masses and crystallizes in polyhedric grains (see Plate 1 Fig. A). In the drawings the ferrite is left white, the black net-work showing the junction lines between the grains. In



A. Carbon, 0 09 per cent. B. Carbon, 0.21 per cent. C. Carbon, 0.35 per cent



D. Carbon, 0 80 per cent. E. Carbon, 1.20 per cent. F. Carbon, 2 50 per cent.

PLATE 1. SERIES SHOWING THE MICROSTRUCTURE OF UNHARDENED STEEL.

The clear areas are ferrite, the cross-lined pearlite, and the black areas cementite. The series shows admirably how, as the carbon increases, the ferrite disappears and the pearlite increases until, at 0 80 per cent. carbon, the entire mass is pearlite. With a further rise of the carbon-content, the pearlite in turn gives place to the gradually increasing cementite

Fig. B, these junction lines are not indicated. In steel of medium hardness, slowly cooled from a high temperature, the ferrite, present only in small quantity, forms a membrane of varying thickness enveloping the grains of another constituent to be described later (pearlite), Fig. 12. If such steel, however, be forged until a relatively low temperature is reached, or if it be reheated to a low temperature, both constituents are more thoroughly mixed, presenting a confused and amorphous appearance. Finally ferrite forms a structural element of pearlite, as will be seen later on.

A slight etching of the polished section leaves the ferrite white and brilliant, and develops the joints between the grains. On etching more deeply, however, some of the grains are darkened or assume a mottled appearance, while others remain bright. Ferrite being the softest of all the constituents is more easily worn away by polishing, being frequently somewhat depressed with regard to the other components.

II. *Cementite.*—This is a combination of iron with cement-carbon, *i. e.*, carbon as it exists in unhardened steel. It answers to the formula Fe_3C.

Cementite begins to appear when the carbon-content rises above 0.80 per cent., immediately after the disappearance of ferrite, and increases in amount with further increase of carbon. When present in large quantity, as in very hard steel, it segregates in relatively large particles, (see Plate 1, Fig. F.). In the drawing of Plate 1 the cementite is shown in black to distinguish it from ferrite. When present only in small quantity, it frequently forms thin membranes around grains of the third constituent (pearlite), as shown in Plate 1, Fig. E. Cementite, like ferrite, constitutes a structural element of pearlite. Cementite remains bright and brilliant, even after repeated etchings. While ferrite is the softest, cementite is the hardest of the constituents, so that it generally stands in relief, especially if the polishing be finished on a soft, yielding support. Cementite, moreover, always remains structureless.

III. *Pearlite.*—A magnification of at least 300 diameters is generally required to resolve the structure of pearlite. It is then found to be made up of minute particles or very thin plates, alternately dark and bright. It is known beyond any reasonable doubt that these components of pearlite are ferrite and cementite. If the steel has been allowed to cool slowly and undisturbedly from a high temperature, pearlite assumes a well defined lamellar structure. If on the contrary, the metal has been forged down to a low temperature, or reheated to a

relatively low temperature, pearlite assumes a granular appearance.

The amount of pearlite in steel increases proportionately to the carbon-content displacing ferrite, until at about 0.80 per cent. of carbon, it forms the totality of the mass. With further increase of carbon, cementine begins to replace some of the pearlite (see Plate 1.). With low powers, pearlite appears dark or gives rise to a beautiful play of color, strongly suggestive of mother-of-pearl, hence its name. A high magnification, as stated above, is needed to reveal its composite structure.

The structure of samples of steel made up respectively of ferrite and pearlite, of pearlite alone, and of pearlite and cementite, is further illustrated, under a magnification of 1,000 diameters, in Figs. 14 and 15, which are reproduced from some beautiful photo-micrographs by Osmond. The laminated structure of pearlite is clearly brought out, and in Fig. 15, it may be readily seen that the cementite (the white portions), stand in relief; the surrounding pearlite, being softer, has been worn away to a greater extent by the polishing operation.

The great similarity which will be seen to exist between the structure of steel and that of binary alloys which form neither definite compounds nor isomorphous mixtures, leads us to consider steel as an alloy of iron and the carbide Fe_3C, *i. e.*, of ferrite and cementite, pearlite being the eutectic alloy of the two components.

The similarity of their cooling curves, whose description however, is beyond the scope of this paper, greatly increases the analogy between steel and other alloys. There is, however, one point in which steel differs materially from ordinary metallic alloys. In alloys the crystallization of the constituents takes place simultaneously with their solidification. Above the point at which crystallization begins, the mass is *liquid*. With steel, on the contrary, the crystallization of the constituents takes place while the whole mass is already *solid*. At a high temperature steel is a *solid solution* of the two components, iron and Fe_3C, which upon further cooling crystallize out, exactly as the component-metals of an alloy crystallize during solidification.

Hardened Steel.—When a piece of steel is suddenly cooled from a high temperature, unless it be very slightly or very highly carburetted, it is found to be made of a single constituent, which has been called "martensite," the structure of which is illustrated in Fig. 16, under a magnification of 1,000 diameters. It appears to be made up of needles frequently crossing each other. The hardness of martensite increases rapidly with the carbon-content and becomes very great.

From what has been said it would seem as if martensite must be that solid solution of iron and the carbide of iron, Fe_3C, existing at a high temperature, retained in the cold metal through sudden cooling, the components having been denied the necessary time to crystallize out.

If the steel contains very little carbon, a small amount of ferrite is found associated with the martensite, while if it be highly carburetted some cementite is found in the metal after quenching.

While the structural composition of metals and alloys is regulated by their chemical composition, it is evident that their physical properties, to which they owe their prominent place in the arts, do not depend exclusively upon the relative proportions of the structural components, but that they depend also upon the distribution, mode of occurrence, size and shape of the individual grains or crystalline particles, and these features are regulated by the treatment, thermal and mechanical, to which the metal is subjected.

The microscope gives us a means of studying these structural changes which are so closely related to the properties of the metal, and thus opens up possibilities in the art as well as in the science of metallurgy whose value can hardly be overestimated.

EDITORIAL COMMENT

Mr. Barrett's article on the far eastern situation, which leads this issue, is inspired by the conviction that the engineering world has the largest interest, and can and should exercise the largest influence, in the settlement of the Chinese question and the attendant problems in eastern Asia.

This is "the new diplomacy"—the striving for expansion of industry, not for the extension of power. It should be plain enough to the industrial world that it must concern itself actively in the matter, and yet its eyes are still dim, its ears still dull, and its voice low or uncertain.

This is more particularly true of the United States; the Briton and the German have been going abroad so long, making the harbours, building the roadways, and opening the mines of the world, that they lead, rather than follow, their governments in the matter of foreign policy. But if America needs to appreciate the irreparable loss which will follow present inaction, England and Germany need to understand that they have far more to gain than to fear from America's entry into the question. The needs of the newly-opening regions of the earth are going to tax—and overtax—the producing capacity of all the industrial nations. There will be wholesome competition for the units of their requirements, of course, but the aggregate will be so great that no one, nor two, manufacturing nations can supply them all. And they must all be supplied, if the development is to go on at all.

But first, stable conditions and an equitable policy must be established throughout the region, and this will never be secured by a savage scramble for fragments of territory or limited "spheres of influence." Will the industrial elements of England, America, and Germany, whose interests are paramount, see in time that these interests are identical and demand from their governments identical action for the preservation, in its entirety, of their undivided interest in the greatest market the world has ever known?

Mr. Orcutt, (whose remarkable articles on Machine-Shop Management, in the pages of this Magazine, have awakened an interest living far beyond the close of the present series), is an apostle of the new school of works management, in which the comfort of the worker is a ruling principle. He preaches, however, by his own avowal, not as a humanitarian but as an economist.

To quote his own humourous phrasing of it, "We don't do it because we love our fellow man, but because it pays." In his August article he put it thus: "As a means of securing and retaining the best workmen, the best appliances for their accommodation and comfort become, of course, a necessity." This is a recognition of the second stage—appreciation by the workers of their improved surroundings. Already the manufacturing world is emerging from the darkness wherein the employer said: "Let them keep warm by working harder"; where the railway put the engine driver on an uncovered foot plate, "Lest he should go to sleep" in quarters made too comfortable. The dark ages have lasted longer in Europe than in America, but they are passing—not, perhaps, because we love our fellow man any better, but because we understand better that "it pays" to reduce waste, wear, and tear—of body and mind, as well as of steam and metal-bearings—of workmen, as well as of work-tools.

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The works manager who "treats his men like machines" has long been held up to execration. But now, with a changed conception of what the phrase implies, it promises to become the ruling idea of the best shops—those in which the men are treated with the greatest apparent consideration.

Not to consider that a man is a machine—fully automatic, driven by an individual motor (in fact, by a complete isolated power plant), capable of a very wide range of work, but very sensitive to bad handling—has too often meant to give to his setting and up-keep far less care and attention than are bestowed on the comparatively rough

and coarse tools of metal. A manufacturer who refused scornfully to heat his workrooms for the sake of the employees, has been known to agree at once to install a warming and ventilating plant when reminded of the advantage to some accurate metal-cutting tools.

The selfishness which was indifferent to the workman's well-being, because workmen apparently cost nothing to install and could be replaced without apparent cost when worn out, was blind not to humanity merely but to its own pocket interest. Installation expense, as a rule, makes but a small factor in total cost, in comparison with the fraction chargeable to operating expense; operating expense is best reduced by increasing output; increased output can be secured only by working a machine under advantageous conditions. The human machine, to attain its maximum output, needs reasonable warmth and light, cleanliness, oxygen, and nourishing food. It needs also certain less tangible elements—called by some writers "sympathy"—which have more or less effect upon that elusive part called its "ambition."

Strange that managers, eager for the utmost of economy in the power plant, keen to increase the efficiency of machine tools, should be so slow to realise the importance and the profit of proper care and up-keep of the human portion of their producing machinery.

* * *

The certain sequence of trust-formation is beginning to appear in the United States, in the form of new concerns organised to fight the big combinations. Even where these latter are as large and as powerful as those which have been formed in the iron and steel trades, courage to compete seems not to be lacking.

Stimulus to such efforts is, of course, afforded by the sudden rise in the wave of industrial activity which has spread over the States. The conditions which prevented English firms from making early deliveries of locomotives, and of other orders recently placed in America, seem now to rule throughout the United States. The demand falls ultimately upon the iron and steel makers, and their capacity is, for the present, overtaxed. Much of the work now under way or projected has been waiting through recent years of depression and economy, and is badly needed. Whether the boom will survive the approaching presidential campaign, however, remains to be seen. It will at least be a time of stern trial for the recently-formed industrial combinations.

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Mr. Rous-Marten speaks of the growing tendency, apparent in locomotive practice, for distinctively national differences in construction to disappear. "The distinctive features of the British and American systems are now but few. Their tendency is to become fewer still." And this is but an instance of a movement which, in its full range, extends throughout every department of engineering work.

With the increase of travel, and the attendant freer interchange of observation; with the extension of engineering literature; more than all, perhaps, with the meetings in exploitation work in new countries and the competition for export trade, engineers everywhere are learning the expediency—more, the necessity—of drawing upon the common fund of experience where it is at their disposal, in place of toilsomely amassing a private store of their own.

This does not imply, by any means, that practice is nearing a dead level of monotony. On the contrary, the opportunity for advance and for individuality is as much greater as the international field is wider, and the international emulation is keener, than the national. With the restrictions of local limits and local prejudice broken away, there is opportunity for such progress as has never yet been realised. But we shall hear less about "English practice," "German practice," "American practice"—and more about *good* practice.

And it is the aim of THE ENGINEERING MAGAZINE to further this movement by making its pages, not the depository of any single national fund of engineering knowledge, but a clearing house into which the funds of all are paid, and in which the totals are determined and the balance struck.

* * *

It is supposed to be one of the advantages of association among professional men that they learn something about each other's work, or at least about its nomenclature;

and, while possibly not always working in entire harmony, they are supposed to avoid such use of identical terms for different things as might cause confusion. That this is not always the case, however, appears in one or two decidedly unfortunate instances.

It might have been supposed that, if there was any one term about whose status there was no manner of doubt, it was the British Thermal Unit, the well-known abbreviation for which is in world-wide use as B. T. U. Now, however, along comes a much later term, having an entirely different meaning, and a good name of its own, *i. e.*, the kilowatt-hour, and not only gets itself entitled the "Board of Trade Unit," but actually has the effrontery to appropriate the time-honoured initials, and behold there is another "B. T. U." in the field. If the two units were used in widely separated lines of work there might be less cause for objection; but, since mechanical and electrical engineering continue to draw closer and closer together, the continuance of this confusion in nomenclature ought to be stopped. The pirate term has not been in use so long that it may not be ousted from its usurped position, especially as it is employed by only a portion of the English-speaking people; but the sooner its use is discontinued, the easier it will be to get rid of what never should have been permitted.

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There is another confusion of meanings for a single term, for which, however, there is a better excuse, as both meanings really refer to the same action, though under different conditions. The word electrolysis, long used in electro-chemistry for electrical decomposition, has been appropriated by the electric-tramway fraternity to indicate the corrosion to water mains caused by stray currents. While this is undoubtedly a form of electrolytic action, it is a destructive form which is distinctly different in general character from the industrial or analytical operations of refining works, of the electrotypers, or of the laboratory. Rusting might very properly be called oxidation, yet it is rarely so dignified, and the electric corrosion, which unfortunately occurs too often as a result of defective rail-bonding, ought to be called by some name more indicative of the fact that it is an unintentional and injurious process.

While upon this subject of names, the question of the proper word to use for a self-propelled vehicle demands attention. Many individuals and publications appear to think that it is necessary that some new word be coined for such vehicles, to indicate that they form a class by themselves and are something distinct from the horse-drawn article. There was good reason to object to the term "horseless carriage," but that awkward term has practically died a natural death, and automobile seems to be the term in favour. But why should there be any specific term, any more than there is to indicate that a horse, a mule, or an ass, is the source of motive power for the older vehicle? Different kinds of carriages have different names, regardless of the nature of their motive power; and if, as many believe, the animal will soon be superseded by the machine, there there will be no need to explain that he is not there, since no one will expect him. Let the old names for the various kinds of wheeled vehicles stand, and let the method of their propulsion take care of itself, or be indicated by response to further inquiry.

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There is a feature appearing in connection with the introduction of electric driving in machine shops, which, although a part of the natural evolution of the subject, has not received the attention it deserves. In former days, and, indeed, not so very long ago, the whole question of machine-shop design and tool arrangement depended upon the motive power. Great works were laid out upon the basis of the location of the engine house, and long lines of shafting formed backbones, along which all sorts of tools were arranged in order that they might get their power to the best advantage. Heavy tools were placed near the source of power, and machines had their location determined by the question of the pull of belts rather than by the work to be done; and, in spite of all, the loss involved in getting the power to the point of action often amounted to 50 per cent. of the whole.

When a new works is to be designed, and electric driving is adopted, the whole basis of action is changed. Instead of the motive power being the prime consideration, it drops into the background, and the estab-

lishment can now be planned, as it should be, with regard to the work it is to perform and with respect to the output. Machines can be arranged in some sort of logical sequence; it is no longer necessary to place the lathes lengthwise of the shop, merely because the line shafting happens to run that way. If the opportunities for efficient operation which this new order permits are fully appreciated, the advantages possessed by a newly erected works ought to be sufficient to give it a lead hardly to be overcome by its older competitors.

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In these days of standards and standardization it is most desirable that practice should be made as nearly international as possible, in order that records of work in various parts of the world may be directly comparable. The International Association for Testing Materials is doing good work in its various lines, and offers an excellent example to be followed in other directions.

There is now a fine opportunity to do either the right or the wrong thing in the matter of testing engines and boilers, and it is to be hoped that the question will be given a chance to reach a proper settlement. There is a committee for the revision of the code for testing steam boilers, composed of members of the American Society of Mechanical Engineers, and it has done much good work, and made several partial reports, while another committee of the same society is preparing to report upon a standard method of testing steam engines. At the same time, the Institution of Civil Engineers has a Thermal Efficiencies Committee at work upon practically the same subject, and, unless some means be devised to effect a co-operation of these two bodies, there must be two independent reports presented and adopted. There certainly appears to be no good reason why the committees of two representative bodies of engineers, practically standing for the science of steam engineering of the Anglo-Saxon world, should not get together and harmonise the details of their work, and present codes which should stand the world over.

At the present time the horse-power stands as a unit in all countries, not because it harmonises with the metric system, but because it is the measure used by the nations who build the steam-engines of the world, and there is little reason to believe that any other standard of engine and boiler performance could find acceptance beside the one adopted by the engineers of England and America. It is to be hoped that this opportunity will not be lost, and that we shall have a harmonious, and not a conflicting code. Such a conference between French and English scientists a hundred years ago might have given us a metre only $\frac{5}{8}$ of an inch longer than the present one, and all would have been harmony instead of confusion in another line of work.

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The very interesting experiments recently made in France upon the resistance of glass to tension, of which a fuller review is given elsewhere in this issue, is an excellent example of the manner in which the practical experience of centuries discovers what the scientists can only learn in the laboratory. It has long been the experience of bottlers of champagne and carbonated waters that bottles which have been under pressure for some time are apt to burst without rule or reason; and without attempting to explain the fact, the experienced bottler objects to the use of old bottles as being more likely to give trouble in this respect. Now comes the scientist and proves, by tests in his laboratory, what the bottler long ago knew. He shows that glass, when subjected to a stress for a long period of time, becomes perceptibly weaker and may at last yield to a load which was at first sustained with ease.

It will often be found that there is a scientific basis for a popular belief, and this is but another contribution to the truth of this impression.

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By an unfortunate oversight, the concluding paragraph of Mr. David A. Louis' paper on the Magnetite Deposits of Swedish Lapland in our July issue was omitted. The few omitted words contained the titles of the last three illustrations, and called attention to the fact that these views are from the Ural, and do not represent places in Lapland. They show very effectively the close resemblance to the methods of mining and transport in the two places, and round out the description of northern mining methods.

REVIEW OF THE BRITISH PRESS

An American Machine Works in England.

THERE has been so much written and said of late about American methods and American tools that the subject is almost worn threadbare. It will now no longer be necessary to journey across the Atlantic to investigate the conditions under which American machine works are operated, since a full fledged American machine shop will soon be in active operation in England. We refer to the new works of the Westinghouse Electrical Company about to be erected at Trafford Park, on the margin of the Manchester Ship Canal, and a description of these works is given in a recent issue of *Engineering* with some interesting comments on the conditions which have led to their construction and which will attend their operation.

Commenting on the changes which have taken place in connection with the operation of machine works, *Engineering* says:

"Day by day business methods are changing; they do not alter because we say so, but as the result of vast forces which are beyond our control and insensible to our influence.

"Economic laws are not made in Parliament, where powerful sections of the community can get clauses inserted defending their interests. We see them gradually coming into action, and those whose eyes are not blinded can sometimes predict the lines of their development for a short way ahead. "Hitherto we have never said that the wolf of American competition had come, although we have proclaimed that it was surely coming." Now it appears in the form of a British manufactory dominated by American ideas, and few who study the signs of the times will fail to appreciate the importance of the news.

It is not often that an enterprise starts under such auspices as does the English works of the Westinghouse Company. Beginning, so to speak, with a clean sheet, it has behind it all the experience gained in connection with the successful operation of the great works at Pittsburgh, while at the same time it is hampered by none of the conservative traditions which have so much influence over the conduct of old-established English concerns.

"The new firm will not start as a beginner who has to feel his way step by step. It will inherit all the patents, drawings, and records of the parent company, and there will be transferred to it the entire accumulated experience of the Pittsburgh undertaking. In all cases of difficulty it will command the assistance of a staff which has demonstrated its ability in competition with the best engineers of America, and thus will be able to undertake risks which would be full of hazard without this aid."

It will of course be understood that in this new works specialisation will be carried to its logical conclusion. The new establishment being in England will be nominally an English works, but in fact it will be an American shop, transplanted, it is true, but still distinctively American. British labour will be employed, but it will be employed on American tools, and operated on American methods. We venture to affirm that the output of the American tools in this establishment will be fully as great as is obtained from similar tools in the land of their origin; and we may further affirm our belief that the men operating them will learn that their wages will depend upon the product of the machines under their care.

There is one thing which the American manufacturer has learned which labour conditions in England have not permitted to be developed in Great Britain, *i. e.*, the fact that it is the wages cost per unit of product that must be considered, and not the wages per unit of producer. It matters little how much money the workman makes provided the cost per unit of product is diminished. Hence the strenuous aim of the American manufacturer is to increase the total output per man, and to do this he arranges and adapts his machinery to obtain as great an output of work with as few men as he possibly can.

Everyone who has visited an American

machine shop has observed how few men proportionally there are in it compared with similar establishments in other countries. One man attending to two, three, or four machines is a most usual occurrence, and in most cases the one man is not working as hard as he would have formerly been attending a single machine, while at the same time he is earning higher wages. If such methods can be successfully introduced into England, they will demonstrate most forcibly both to English employers and English workmen that the old-time methods can no longer be continued.

"In warning our readers against the perils of American competition, we are preaching no original doctrine. There are many firms who saw the danger years ago and who guarded against it. We could name shops where all that is good in American practice has been assimilated and modified to meet British needs, where no machine-tool is retained after it is out of date, and whose owners can face foreign competition in any market where they have a fair field. It is our boast that Englishmen never know when they are beaten, but it is a saying that can be read two ways. Wilful ignorance of danger is no safeguard, and blind neglect gives no augury of victory. We have still abundant capital and great skill, but we are handicapped by our conservative instincts. There are too many among us who grumble that they should be obliged to change their ways, and cling with desperation to their old methods. They are just in the position of the old-fashioned tradesman who refused to learn the cheaper methods of the stores and prided himself on his aristocratic connection, until he awoke one day to find that it had left him. It is, indeed, a hard task to revivify a failing business, and we would warn our readers against getting into the position of having to attempt it. There is no secret about modern methods; he that runneth may read them if he will."

Automatic Couplers.

THE agitation in connection with the question of the use of automatic couplers on railways appears in the form of various articles in the technical press, the *Engineer* especially devoting much space in several issues to the subject. In addition to verbatim reports of the sittings of the Royal Commission, there is a report upon the use of automatic couplers on American freight cars and a very complete and lucid account of the manner in which such couplings have been introduced in the United States.

Since the practice in America is being extensively referred to as a precedent for the introduction of automatic couplers in Great Britain the conditions which led to the successful realisation of the matter in America are certainly worthy of study.

The introduction of automatic couplers was not accomplished on the American railways without much opposition, and indeed all the freight cars are not yet fitted out with them, but by law the complete equipment of all the railways must be completed by the first of next January, and the means by which this has been accomplished are of interest. For many years there had been a direction of inventive talent towards the subject of couplers, so much so that the records of the Patent Office teemed with all sorts of devices, good, bad, and indifferent, all endeavouring to win the great prize which must fall to the inventor whose device should be adopted. It was the prolific nature of the subject which did much to delay the introduction of any of the devices, since nearly every inventor failed to realise that interchangeability was the one essential which must be secured. In the United States the cars must pass from line to line, and be made up in trains from every part of the country, and unless the coupling devices on a car would enable it to form a portion of a train of cars of other lines than its own, they would be useless.

It is evident that some standard form must be adopted, at least so far as the shape of the connecting parts is concerned, although there is no particular reason for the other features of the mechanism being the same on all cars. It was the necessity for uniformity of actual coupling parts which led the Master Car Builders Association to adopt the so-called Janney type as the standard, and as the owners of the Janney patents waived their patent rights on the form of knuckle and coupling-head, this paved the way for the introduction of interchangeable couplers. This was followed by the petition of the brakemen to the Interstate Commerce Commission, and

the subject was commented upon in the President's message in 1889. In 1893 the "brake and coupler act" was passed, requiring all cars to be equipped with automatic couplers before 1898, but at the expiration of this time it was found to be necessary to grant an extension of time to January 1st, 1900, and semi-annual reports as to the progress of the work of equipment were required. More than 80 per cent. of the cars are now equipped, and the work will doubtless be completed by the expiration of the time limit.

The result of this enforced introduction of automatic couplers is a demonstration that the couplers are not only desirable from a humanitarian point of view but are also very advantageous for operative reasons. This is especially true when the trains are also equipped with air brakes, and there is no doubt that trains fitted with continuous brakes and tight couplers can be run at higher speeds over steep gradients with less fear of their breaking apart than was possible with the old pin and link coupling. The greater facility with which trains can be made up and handled forms an important element of economy, and the absence of waste energy in bumping and jerking the cars, so apparent with the old loose couplers, is avoided, and a saving in power and a reduction in wear and tear naturally follows.

The experience which has been had in America in this important subject should be considered in all its bearings in connection with the question as it has come up in Great Britain. It is really only one form of the whole broad subject of re-equipment of works about which so much has been said of late. To argue against a manifest improvement simply because it means a large outlay and a superseding of existing plant will not do. It is just such arguments which have kept many obsolete devices in operation long after they have outlived their usefulness, and it is a consequence of such mistaken policy that we find so many things in use to-day which should long ago have gone to the scrap heap. The true question should not be, "can the railways afford to have their cars equipped with continuous brakes and automatic couplers," but rather, "can they afford longer to go without so equipping them?"

The Irish Channel Tunnel.

THE revival of the scheme for a railway tunnel to connect Ireland with England has been the occasion for various articles in the engineering journals, and an editorial in the *Engineer* discusses the subject in a characteristic manner.

The political side of the question appears in the proposal that the British Government guarantees the interest of 3 per cent. on £12,000,000 for an indefinite period, and while this has nothing to do with the engineering features of the scheme it shows that some other inducement than that of the prospect of immediate returns from the operation of the tunnel is thought necessary.

Apart from the political side of the subject, the tunnel may properly be regarded as a matter of engineering, and as such the scheme demands consideration from the engineering point of view. Unfortunately the promoters have presented little or no information upon which an engineering opinion can be based.

"Lord Charles Beresford has been credited with saying that so long as money enough was forthcoming engineers could do anything. We fear that he has formed rather an exaggerated estimate of our powers. We are quite unable, at all events, to say whether the proposed tunnel could or could not be made, simply because no positive information on a most important point is available. No one knows what faults exist in the bottom of the channel. It is proposed that the railway shall pass 150 feet below the sea bottom. No borings have been made in mid-channel. The whole region manifests signs of violent volcanic action. The construction of the tunnel would be commenced absolutely in the dark as to the condition of the strata to be passed through; how far it is fissured, how far saturated, no one has any accurate information."

Under these circumstances it is rather difficult for any engineer to form an opinion upon the cost, or even the possibility of the construction of a tunnel under the Irish Channel, and until such information is forthcoming, no estimate of the probable earnings can well be made. The only thing under the circumstances which can be done is to make a comparison between the pro-

posed route by tunnel with existing means of transport, and see what the present competing conditions are. This has been done by the *Engineer* in a manner which shows the advantages of a tunnel, so far as saving in time is concerned to be very slight. Taking the time by railway from Belfast to Dublin at 2½ hours, by boat from Dublin to Holyhead at 3 hours, and the run from Holyhead to London at 6 hours, we have Belfast now placed within 12 hours of London, or allowing for contingencies the time may be placed at 13 hours regularly.

The tunnel scheme involves a tunnel about 30 miles long, and the time required for the run can safely be put at one hour, while the terminal in Scotland would be at some point not less than 414 miles from Euston. Allowing 10 hours for this run, and one hour for the time from Belfast to the tunnel entrance, we have 12 hours for the entire distance between Belfast and London, or only one hour saved by the tunnel over existing means of transport. Since the Irish railways are of a different gauge from those in England through trains cannot be run, and the difficulty of breaking bulk and reloading appears in the tunnel plan as much as it now does in the water route. Taking all these conditions into account it certainly appears as if some extraordinary inducements other than those yet offered should be shown before any such expenditure as £12,000,000 would be warranted.

It is certainly worthy of note that when land transport exists, advocates are always ready with some plans for the opening of water communication, and that, on the contrary, when water transport is already naturally available, either bridges or tunnels are as actively urged. Both doubtless have their advantages, but wherever one of them already exists, there advocates will always be found to urge the construction of the other.

The Launching of a Battleship.

THERE have been many articles and books written about the construction of various forms and kinds of ships, and profound treatises are to be had upon every portion of marine architecture, with the exception of one very important point, *i. e.*, the operation of getting the completed vessel into the water. This is no new problem, and we read that even Robinson Crusoe came to grief in his first experiment in boat-building because he had made no plans to get the hull upon which he had spent so much labour into the water where alone it could be of any service to him.

The recent meeting of the Institution of Mechanical Engineers at Plymouth naturally brought many subjects connected with ship-building into prominence, and among these one of the most interesting was the paper of Mr. H. R. Champness upon the launch of a battleship, as illustrated by the launch of H. M. S. "Ocean" at Devonport dockyard.

A ship is essentially a form of box girder, but it differs from a bridge girder in that it is intended to be supported in equilibrium throughout its entire length and is not constructed to resist the stresses which would come upon it when supported at a few points only. For this reason it is most important that the hull should be properly supported at many points during the course of construction, and especially necessary that the transition from the ways to the water should be effected without the production of serious strains.

All this work demands engineering skill of a high order, but it must be based upon practice and experience, since there are many elements for which accurate data are lacking and it has been only by numerous failures and mishaps that the present system of launching a ship has been successfully developed. Engineers without such experience have attempted to launch ships by novel methods, but in some instances, such as that of the Great Eastern, they have come to grief, while in others the methods used have not been repeated, but a return has been made to the general practice of shipbuilders.

The paper by Mr. Champness gives a detailed account of the construction of the cradles in which the ship is supported during the launch, and numerous illustrations show how much care and thought has been given to the distribution of the pressures and the provision for the strains. During the construction of the ship a careful record is kept of all the weights which are put on board as well as their distribution, and as the work progresses the supports are in-

creased in strength and number, so that when the launching date arrives the launching weight is known very closely. The "Ocean" was by no means unusual in size or weight, the launching weight being 7,110 tons, as compared with the 11,000 tons of the "Oceanic," but the mean pressure per square foot of cradle for the latter ship was only 2.35 tons as compared with 2.5 tons for the "Ocean." The pressure differs at various points during the launch, and as buoyancy is gained in launching, a point is reached when the fore end of the cradle is alone in connection with the groundways, and it is there that the local stress in launching is greatest.

In order to insure the absence of any alteration of form during the launch it is best to provide internal shoring, and in the case of the "Ocean" wooden shores were fitted within at points resting upon the cradle in order to distribute the pressure. All compartments below the calculated launching depth are completed and tested and the doors closed and fastened, and every inlet and discharge through the ship's bottom is tested and certified to be tightly closed, any neglect of such precautions being a possible source of disaster.

During the construction of the ship, after she is well set up, means are provided to ascertain how much the elasticity of the structure has permitted alterations of form, sight battens being fitted both longitudinally and athwartships from which measurements can be taken before and after launching in order to discover the extent to which any hogging or sagging may have occurred.

The cradle was prevented from moving, in the case of the "Ocean" by the use of two "dog shores" one on each side, these acting as struts between the cradle and the ground ways. At the moment of the launch these dog shores were knocked away by the drop of heavy weights, released by cutting the manila rope from which they were suspended. In order to provide for any possible delay in starting hydraulic rams were provided on each side to start the motion as well as one beneath the stern to ease the vessel off the groundways.

In the paper of Mr. Champness the method of lubricating the ways, and many other details of work connected with the launching of a ship are given, the whole forming, so far as the author is aware the first connected and detailed account of the principles and work involved in the launch of a large battleship.

The Durability of Water-Tube Boilers.

THE question of the durability of the tubes used in water-tube boilers is a matter of such importance that the paper by Mr. A. F. Yarrow before the Institution of Naval Architects giving details of his tests of tubes will be received by engineers with much satisfaction.

The experiments were made to determine the relative durability of tubes of mild steel and of nickel steel, the mild steel tubes being such as have hitherto generally been used in water-tube boilers, and the nickel steel tubes containing from 20 to 25 per cent. of nickel.

The causes of the deterioration of boiler tubes are given as (1) action of acids in the water, due to the presence of grease, (2) oxidation on the outside by the action of the furnace gases, and (3) deterioration on the inside by the action of superheated steam.

Mr. Yarrow endeavoured to repeat as nearly as possible the conditions which exist in actual practice, and by exposing both kinds of tubes to the same influence, to determine the relative resisting power of each.

The corrosion test was made by suspending weighed pieces of each kind of tubing in dilute hydrochloric acid for periods varying from 21 to 168 hours, the extent of the corrosion being determined by the loss of weight in each case. This test showed a remarkable advantage in favour of the nickel steel, the loss by corrosion of the mild steel tube being 16½ times what it was in the nickel-steel tube. Mr. Yarrow remarks that it may be contended that the relative corrosion of the two specimens when using dilute hydrochloric acid does not correspond with what it would be with such acids as are present in boilers under working conditions, but says, that it is not unreasonable to suppose that it may serve as a guide.

The second test was intended to show the action of gases and fire upon the exterior of the tubes. In this experiment two tubes

were placed in a small brick furnace arranged so that they would be heated under identically the same conditions. The extent of the corrosion by the action of the heat and gases was determined by the loss in weight after repeated heating and cooling, the scale being removed between each heating, and the tubes weighed to ascertain the rate of loss. After five such heatings, coolings, and scrapings the nickel steel tube was found to have lost about 27 per cent. of its weight, and the mild steel tube 76 per cent., thus showing that the nickel steel resisted fire corrosion 2.9 times better than the mild steel.

Since these tubes had no steam on the inside, a further series of tests were made at the instance of Sir John Durston, to determine the effect of superheated steam. In these tests the tubes were placed in a furnace side by side, and fed with steam at one end, the pressure of 60 pounds per square inch being maintained at the inlet and the steam allowed to escape slowly at the other end. This kept the tubes filled with highly superheated steam, and the corrosion from the steam within was added to that of the fire without. In this trial the loss of weight of the nickel-steel tube was much less than that of the mild steel, and after 10 hours the mild steel tube gave out and had to be replaced. A second mild-steel tube gave out before the nickel-steel tube began to leak, and the durability of the nickel-steel tube was recorded as 21 hours against a mean of 9 hours for the two mild-steel tubes.

Since the question of expansion and contraction has an important bearing upon the question of water-tube boiler construction, tests were made to ascertain the relative expansibility of the two materials. By raising the temperature to a dull red it was found that the nickel steel expanded the most, the relation being as 3 to 4, and hence it would be inadvisable to use both kinds of tube side by side, as leakage due to the unequal expansion would be likely to occur.

The general conclusions to be drawn from these experiments are so entirely favourable to the use of nickel steel that Mr. Yarrow expresses himself as convinced of its eminent superiority over mild steel for use in water-tube boilers. As regards acid corrosion there would be a vastly longer life for the nickel steel tubes than for the mild steel ones, while as regards deterioration from the action of heated gases or steam the former has at least twice the durability of the latter. So far as the question of cost is concerned it is quite possible that the longer life of the nickel steel, together with the saving of labour in replacing tubes, may make it less expensive in the long run than the apparently cheaper material.

Ice-Breaking Steamboats.

MENTION has already been made in these columns of the powerful ice breaking boats which have recently been constructed for use in Russian waters, and at the recent meeting of the Institution of Naval Architects an interesting paper upon the construction of these very effective vessels was read by Mr. H. F. Swan.

For a long time the ports on the Baltic have been endeavouring to obtain some relief from the obstruction which ice offers to navigation, and various forms of ice breakers have been constructed, but until recently such boats have not been very effective in keeping the harbours open.

Up to three or four years ago the principle upon which these boats operated was that of climbing up on the ice and breaking it down by sheer weight. For this purpose the forefoot was cut away from a point on the stem above the water line in a slanting direction, striking the keel about one-fourth of the vessel's length from the bow. A boat of this form, when provided with powerful engines, could be forced up on to the sheet of ice, and if the latter was not too thick it would be broken down by the weight of the boat and a channel thus forced through.

Experience with ferry boats provided with a propeller at each end, however, showed that the disturbance of the water by the forward propeller has a very powerful disruptive influence on the ice. In 1893 this principle was embodied in the American ice breaker the Marie, and since then several very effective boats have been constructed on this principle for use in Russian ports. Of these modern boats the Ermack is the most celebrated as well as the most powerful. This most successful ice

breaker is of 8,000 tons displacement and 10,000 horse power, and is provided with three propellers aft and one forward. Both bow and stern are provided with an exceptional amount of overhang and the sides are inclined outward at a considerable angle from the vertical to prevent crushing when nipped in the ice. Internally the framing is of great strength, there being 48 compartments, while externally the surface is made as smooth as possible, both butts and seams being flush-plated. The vessel is also fitted with pumps of great power, connected with trimming tanks at the bow and stern and on the sides, so that if the boat gets caught in the ice the horizontal plane can be varied in any sense desired, thus assisting in manœuvring.

"Experience with the Ermack has shown that she has broken composed ice of 8 ft. 3 in. in thickness, and she has gone through field ice of about 40 in. thick with 6 in. of snow upon it, at a speed of 2½ to 3 knots; moreover, she has been driven at a speed of about 10 knots through clear ice of 24 in. thickness, whilst ice under 18 in. has little effect upon her. It was found that snow has a wonderfully great influence upon an ice breaker, much more so than a similar thickness of solid ice."

The commercial value of such a vessel is shown by the fact that immediately upon her arrival the Ermack liberated thirty-three steamers from the harbour of Reval, after which she proceeded to Cronstadt and St. Petersburg and opened the port several weeks before it would otherwise have been possible, and enabled forty vessels to enter.

It has been suggested that vessels of this type might be valuable aids in connection with Arctic explorations, but it must be remembered that the conditions are not altogether similar. In the Baltic the ice is formed gradually at moderate temperatures, and the same result could not be looked for in the case of service in the Arctic regions, where the ice is of a much harder and more brittle nature.

Mr. Swan's paper gives some interesting information about the powerful train ferry boats constructed for use on the Volga and on Lake Baikal, and gives full credit to Admiral Makaroff, of the Imperial Russian Navy for the initiative in connection with the Russian ice breakers.

Atmospheric Railways.

THE general introduction of pneumatic dispatch tubes for conveying mail to and from sub-station post offices, as well as small packages in commercial establishments, renders the historical account of the early atmospheric railways presented by Sir Frederick Bramwell at the meeting of the Institution of Mechanical Engineers a matter of much interest.

At one time it was thought that atmospheric pressure was likely to become an important means of propulsion for railways, and the experiment, as related by Sir Frederick was carried out upon a large scale under the supervision of an engineer of the skill and ability of the late Isambard Brunel.

The principle of the South Devon Railway, which formed the main subject of Sir Frederick Bramwell's paper, was devised by Clegg and Samuda, and involved the use of a vacuum pipe beneath the track between the rails, the pipe being fitted with a piston impelled forward by atmospheric pressure when the air was exhausted from the tube. An arm extended up from the piston and was attached to the leading carriage of the train and thus the entire train was drawn along. It will be seen that this arrangement involved a slot along the entire length of the tube, and the main problem of the system was the method of keeping the tube air-tight and at the same time permitting the arm to reach out and be connected with the train. This part of the device was the much-talked-of "valve," and really consisted of a strip of leather, like a belt, which lay along the entire top of the tube, there being a flat seat there constructed for it, the vacuum in the tube causing this belt to be held down tight by atmospheric pressure. The arm which came up through the slot was attached to the piston on the side away from the exhausted portion of the tube, and was provided with a yoke through which the belt-valve was lifted up, rollers being connected in front and behind the arm in such a manner as to lift and close the valve before and after the passage of the arm.

It will readily be imagined that such a device was not easy to keep tight, especially with such mechanical appliances as were available fifty years ago, and an interesting

portion of Sir Frederick's narrative relates to the difficulties which were encountered.

When the apparatus worked all right the railway was very pleasant, there being no dust, smoke, nor cinders, but when the valve did not close air-tight the engine pumped on in vain and the train had to wait helpless at the station.

The road, from Exeter to Newton, was about twenty miles long divided into sections of about three miles in length, each section being provided with its own pumping station, and the system was operated more or less completely from 1846 to 1848.

As might be supposed, the efficiency of such a system was not high, large losses from leakage being inevitable, and according to Brunel it required 865 horse-power to perform work represented by 300 horse-power, an efficiency of about 35 per cent.

Although this interesting experiment has been obsolete for more than fifty years it is interesting to note how in many ways it was an anticipation of some modern successful systems. It is very closely represented to-day by the cable tramway systems which are in successful use in many places, the real difference being mainly in the fact that a cable of wire rope does the work which Brunel attempted to do with a cable of air. The conduit has its slot, and the arm from the car extends down into the tube, but with the cable tramway no valve is required, and the engine at the power station has its direct connection to the train without risk of leakage. In most respects the cable has all the advantages which Brunel expected to gain by the atmospheric tube. The smoke, smell, and noise of the locomotive are all absent, and all the advantages of stationary power stations are attained, while the control of the car, especially for the frequent stoppings and startings required by local traffic, is much better.

Still more nearly resembling the atmospheric railway in some respects is the modern electric tramway, especially when the underground conduit system is used. Here all the advantages which Brunel hoped to realise are attained with none of the difficulties against which he contended. Although the electric current flows through the conductors it is even less apparent than the air pressure of the older system, while the absence of reciprocating parts and the general smoothness of motion and all the other advantages so well described by Sir Frederick Bramwell are completely attained.

In these respects at least the account of the old atmospheric railway certainly forms a most interesting bit of mechanical history, showing how many desirable features were anticipated only to be realised in a different manner fifty years later.

REVIEW OF THE CONTINENTAL PRESS

Electrical Conductivity at High Temperatures.

SINCE the public announcement and demonstration of the Nernst incandescent electric light there has been much interest manifested in the behaviour of various materials as regards their conductivity at elevated temperatures. A paper upon this subject has been read by Professor Nernst before the recent convention of the German Electrochemical Association, and published in the *Zeitschrift für Elektrochemie,* giving some valuable information in this connection.

Within very wide limits the conductivity of metallic substances is almost independent of temperature, although at very low temperatures the conductivity is greatly increased and at very high ones much diminished. For electrolytic conductivity the opposite effect appears, and at very low temperatures, such as the boiling point of liquid air electrolysis no longer takes place, while on the contrary fused salts are especially good electrolytes.

That electrolytic action may also take place in solids is now generally admitted, and the theoretical discussions of van't Hoff go far toward rendering such action intelligible. The experiments of Professor Nernst himself show, in connection with the use of solid electrolytes as incandescent illuminating bodies, that the increase in conductivity at high temperatures is far greater than has hitherto been believed.

Professor Nernst's experiments were made by pressing the pulverised material into small rods with platinum connections at the ends, and determining their electrical resistance while in a small electrical furnace formed of a platinum spiral enclosed in asbestos. The temperatures were determined at the same time as the resistance, the platinum-rhodium pyrometer of Heraeus being employed.

These experiments showed that pure oxides showed a very slight increase in conductivity, even when raised to incandescence, the conductivity remaining very low at all times, while on the contrary mixed substances in some cases showed a very high increase in conductivity, almost as great as that of fused electrolytes. This action is especially apparent with mixtures of oxides of magnesium, silicon, zirconium, etc.

Fearing that the incandescent medium might be rapidly decomposed by electrolysis, Professor Nernst at first used only an alternating current, but his later experiments have been made with continuous currents. In the course of these experiments it appeared that a rod composed of mixed oxides could be maintained at incandescence for hundreds of hours by means of a continuous current without showing evidence of destructive decomposition. At first this action might be supposed to indicate a conductivity similar to that of metallic substances, but further investigations show that such is not the case. When some of the oxides are colored, as in the case of iron or cerium, it is found that these gradually travel toward the cathode, and if there is much magnesia present in a pencil it is found that the cathode end becomes the larger. During incandescence it is to be observed that the cathode is always much darker than the anode, which may be explained by the tendency to liberate metallic particles at the cathode and rendering that portion a better conductor, while the evolution of oxygen at the anode increases the resistance there.

Apart from the uses of the device for lighting, it appears that other practical applications may be made. Professor Nernst calls attention to the fact of the remarkable constancy of the resistance of a given pencil for given temperatures, and suggests that by the use of electrodes of iridium in connection with a pencil of mixed oxides a reliable and convenient pyrometer for high temperatures may be constructed.

In connection with the discussion upon the paper of Professor Nernst it was suggested that the migration of the coloring matter towards the cathode might indicate a method of removing objectionable color-

ing substances from precious stones. If it were possible to decolorize black diamonds by this process a field of enormous possibilities would be opened, and with other gems important transformations might be effected. While distinctly stating that this had not yet been successfully accomplished, Professor Nernst conceded it to be a possibility, although in the case of the diamond the very low electrolytic conductivity of fixed carbon offered a great difficulty to the practical realisation of the important result.

Railway Terminals in Paris.

AMONG the many changes and improvements in Paris which have been caused by the approaching exposition some of the most important are naturally those intended to assist in providing increased transportation facilities. Nearly every railway possessing a terminal in Paris has been expanding the accommodations to the utmost, while extensions of main lines, and the acquisition of suburban connections have been carried on with the one end in view of providing for the expected increase in travel.

Naturally the greatest of these works is that of the extension of the Orleans Railway from the Place Valhubert to the Quai d'Orsay, and the construction of the magnificent new station on the site of the old Cour des Comptes. This important work has already been described at length by Professor Boyer in the April issue of this magazine, but since that time important progress on the work has been made and described in recent issues of *Le Génie Civil, La Revue Technique* and other technical journals. At the present time the work is well advanced on the subway, which is about two and one-half miles long, and the photographs recently issued show the construction to be of a character which in no way detracts from the appearance of the quay or river front.

The question of motive power for use on this section of the road has been under consideration for some time, and it is evident that ordinary steam locomotives are unsuitable for the conditions. Besides the stretches of open subway and of intermediate tunnelling, in both of which the smoke and gases from locomotives would be most objectionable, the entire trackway of the terminal station is on the lower level, with the waiting rooms, hotel and offices above. To have this lower floor filled with smoke and gas, rising through the floors above to poison the air, would be most objectionable. After a consideration of the possibilities of fireless locomotives, compressed air, and similar substitutes, a commission was sent to the United States to examine into the subject of electric traction there, and as a result it has been decided to use electric locomotives entirely to haul the trains from the Gare d'Austerlitz to the new station. The old terminal will be preserved intact, and used for as much of the traffic as possible, while the bulk of the passenger travel will be delivered into the heart of Paris by means of the new subway without any of the inconvenience ordinarily experienced from smoke, dust or gas.

The Eastern Railway of France will retain its terminal on the rue de Strasbourg, but is making extensive enlargements. An entire block of houses has been acquired, and two small streets which divided the property from the old station have been vacated, and the whole is being taken into the roofed area of the station. This will permit the removal of the inward-bound baggage department and the covered court for arriving passengers to be thrown into the space for the train shed, while at the same time greatly improved quarters for the arriving travellers will be provided in the new portion. An electric transfer table is also to be installed in order to enable trains to be made up with greater ease and dispatch than is now possible by the use of turn-tables. A very full account of these improvements is given in *La Revue Technique,* with plans of the old and new stations, and elevations of the train sheds and court-yard roof.

The Western Railway of France has increased its importance and local capacity by the acquisition of three suburban lines. The first of these is that of the ceinture or belt railway which skirts about the fortifications, and from which subways are being constructed giving direct access to the Champ-de-Mars and the grounds of the exposition. The other lines are those from Issy to Viroflay, and from Plaisir-Grignon to Epône, which will not only control their present local traffic, but will also permit the

trains from Normandy and Brittany to be directed at will to any one of the three stations of St. Lazare, Montparnasse, or the Invalides.

A full account of the work upon these lines, with sections of the necessary subways, is given in the *Revue Générale des Chemins de Fer,* together with much interesting information concerning the application of electric traction which is to be made of these lines.

The whole subject of electric traction on main-line railways is being given serious consideration in France, and apart from these local and subway installations which are being made within the city of Paris some extensive experiments with electric locomotives have been conducted on the Paris-Lyons-Mediterranean Railway. A recent issue of *Le Génie Civil* describes some of these electric locomotives of 45 tons weight, capable of hauling trains of 100 to 150 tons weight at speeds of 60 to 75 miles an hour. These locomotives are operated by accumulators, which are charged from generating stations situated on the Swiss frontier and in Haute-Savoie, at the foot of Mont Blanc, where abundant water power is available. The weight of the accumulators, so far from being objectionable, is in this case of service in securing the necessary adhesion, and the trials which have been thus far made have been most satisfactory.

Water Hammer in Steam Pipes.

THE question of the strength of pipes, valves and fittings is one which has been discussed in various quarters of late, and serious accidents have called attention to the importance of providing ample strength in all steam connections. There should be no difficulty in providing for all the regular working stresses upon pipe connections, but in practice it is found that there are shocks and so-called hammer-blows, the full force of which it is difficult to measure or estimate.

The results of recent investigations upon this subject by M. Walckenaer have recently been published in the *Annales des Ponts et Chaussées,* and the matter is of sufficient interest to bear review and discussion.

The conditions which exist in a pipe containing steam and water of condensation are peculiar, and not always fully understood. When a pipe contains air or a similar gas, there is an elastic cushion formed which, in case of a sudden arrest of flow of water, absorbs the shock, and acts like a spring to prevent any serious hammer-blow. When, however, the closed end of the pipe contains steam, the projection into it of a volume of water may cause a sudden condensation, entirely removing any elastic cushion, and permitting the occurrence of a violent shock.

It is hardly practicable to compute the magnitude of the blows which are thus produced, but it is well known that they may cause serious ruptures in connections amply strong for all ordinary working pressures. M. Walcknaer cites certain experiments made in the German navy, in which pressure gauges placed upon the pipe showed sudden impact pressures ranging from 500 to 2,000 pounds per square inch. A number of examples are cited at length, giving details of accidents all of which show a strong family likeness, stop-valves between boilers being violently ruptured when communication was opened too suddenly between connections of marked difference in pressure. There appears to be little or no doubt that in most if not all of these cases the hammer blow which caused the rupture far exceeded any normal working pressure.

Such accidents may generally be avoided by using care in making such communication, as the valves should be opened so gradually as to prevent a sudden rush of water and steam together. In many instances, however, it is not practicable to avoid shock. The connections between engines and boilers are sometimes so arranged that very serious water-hammer impacts may be produced. M. Walckenaer cites cases in which the connections were such as are frequently found in practice.

In all of the accidents described by Mr. Walckenaer the connections were so arranged that an accumulation of water of condensation in the pipes could occur. In one instance the ruptured valve formed a portion of the connection to a boiler which was out of use and cold while others in the same battery were in service. The opening of a valve permitting steam from a live boiler to flow into the general steam main caused a violent water hammer back

against the valve on the cold boiler, causing rupture of the valve body with serious scalding of the attendant. This system of connecting a number of boilers in battery to one steam main is a very general practice, and while it possesses numerous advantages it has the defect of providing space for the collection of water at various points. Steam traps for the drainage of all places of accumulation of water should be provided, and such traps ought to be of liberal capacity, in order that the drainage may be prompt and effective. Even when a system of piping is altogether free from water at the time of starting the rapid condensation of steam which at first occurs may provide sufficient water to cause violent pounding, and this can only be prevented by a gradual warming up of the whole system, the admission of steam being so gradual that the traps can take care of the water of condensation as rapidly as it is produced; the full volume of steam being admitted only after the pipes have become hot.

The Dusseldorf-Krefeld Tramway.

At the time of the account of the construction of the bridge across the Rhine at Düsseldorf mention was made in these columns of the fact that the company undertaking the bridge construction had also obtained a concession for the construction of an electric tramway to Krefeld, including the right of way over the bridge into the city of Düsseldorf. This tramway is now completed and in operation, and from a paper read before the *Verband Deutscher Elektrotechniker* and published in a recent issue of the *Elektrotechnische Zeitschrift*, some of the more important features may be taken.

Krefeld, an important manufacturing town, is on the opposite side of the Rhine from Düsseldorf, and the latter city has until now had no convenient communication with it, while there had for some time been a steam railway from Cologne to Krefeld by way of Neuss. When the new Rhine bridge was completed it was seen that the electric tramway which had been planned between Düsseldorf and Krefeld would have to compete in speed with the steam road if the traffic with Cologne was to be met. We have therefore in this case a direct competition between steam and electricity, which, if not on main-line railways, is at least operating under somewhat similar conditions.

This competition involved for the electric railway, higher speed than would otherwise have been the case, and hence it was found necessary to avoid highways and conduct the road over an isolated track, passing in close proximity to the various villages on the way but not passing directly through them. The total length of the railway is about 14 miles, a little over 10 miles being in the open stretch between the two cities, and, possibly, with a view to further extensions, the road-bed construction and general equipment, other than electrical, has been made to correspond to the standard requirements of the German State Railways.

For the electrical equipment, which has been constructed by Messrs. Siemens & Halske, the overhead trolley system has been adopted, with the exception of a short section in the central portion of Düsseldorf, where accumulator traction was at first proposed but where it has finally been decided to employ the underground trolley.

In order to keep the cost of construction down it was decided to use as high a pressure as practicable, 600 volts being adopted, and as the road is isolated and protected it would have been possible to use higher pressures had it not been thought desirable to arrange for possible future connections with the local tramway systems in the two terminal cities. In order to provide against possible interruption through breakage, two trolley wires have been stretched, the Siemens sliding collector being used instead of the trolley-wheel, and the return made through the rails as usual. The motor cars are with bogie trucks, as there are a number of sharp curves on the line, there being a 40 h. p. motor on each axle of the motor truck, with direct connection, no gearing being used. Powerful motor cars were planned because the work partakes much of the nature of regular railway traffic. There are passenger trailers to be hauled, and market produce cars as well, while covered goods wagons of the regular German type are to be attached whenever general merchandise is to be transported. The road is thus a regular light railway for general traffic with passenger motor cars instead of

locomotives, and is operated in competition with a steam road for general business.

At the terminals, and for the short distance local business a few miles out, there is a regular service at short intervals, and the speed is there limited to the conditions of operation, but out on the main line, over which half-hourly trains are run, the speed is increased to 25 to 35 miles an hour.

This railway, which occupies a middle position between the steam road and the local tramway, has been in successful operation since the beginning of the year, and has shown a continually increasing traffic, and while the conditions which led to it were in themselves exceptional, yet in operation it may show that for such intermediate lines electricity possesses advantages which will lead to its extended introduction for general traffic.

A Study of Power Gas.

THE increasing interest which has appeared of late in the use of internal combustion motors has led to a corresponding attention to the improvement in apparatus for generating gas which should be available for use in motors and at the same time less costly of production than illuminating gas.

Prominent in this branch of engineering the name of M. Lencauchez has been associated, and the presentation of a long paper by him before the *Société des Ingénieurs Civils de France* upon gases for motive power is worthy of especial notice, particularly as it drew forth an animated discussion from others engaged in similar lines of work.

M. Lencauchez gives a complete classification of the various kinds of combustible gas which can be commercially manufactured, including the gas distilled from bituminous coal, and the gases which may be distilled from lignite, peat, or wood, also water-gas made with anthracite, or with wood, as well as the various kinds of producer gas.

The original work of M. Lencauchez is mainly known in connection with the gas producer which bears his name, and which has been extensively employed for the generation of a cheap, clean gas for use in internal combustion motors. Recently there has been much attention given to the process of M. Riché, which produces from wood a much richer gas than can be made in the ordinary fuel-gas producer, besides rendering a valuable by-product of charcoal, and M. Lencauchez devotes the greater portion of his paper to a comparison of the two systems. Apart from the interest which may be attached to the methods directly discussed in the paper, the whole subject of fuel and power gas is becoming one of general importance and the general information which is given in the discussion therefore raises the paper from its special position into one of wider value and application.

The cost of distilling bituminous coal prevents its application and a method of producing power gas, this process being profitable only for the generation of illuminating gas, or for power in cases in which convenience outweighs cost. Gas distilled from lignite, peat, or wood is so little used as to demand no further attention, and M. Lencauchez passes on to water gas and producer gas.

Water gas made from coal has not been found economical as a source of power, but when enriched by hydrocarbons it has found a wide application for illuminating purposes. When wood, however, is distilled in such a manner that the water contained in it, as well as the tarry liquids, are caused to pass through the incandescent carbon, a form of water-gas of high calorific power is produced which is claimed to be well adapted for power generation. It is this process which bears the name of M. Riché, and which bids fair to become a commercial rival, in certain localities at least, to producer gas as a source of power. Producer gas, as is well known, may be generated simply by burning coal, coke, or coal-slack, with a supply of air insufficient to permit complete combustion, the result being a gas consisting mainly of carbonic oxide and nitrogen, which while of a low calorific power is also of very low cost. It is to this class that the discharge gas from blast furnaces belongs, concerning the application of which so much has of late been said.

In comparing these different kinds of gas, so far as their commercial efficiency in power generation is concerned, it is necessary to take into account not only the calorific power, on which the value directly depends,

but also the cost of generation, and hence it follows that the richest gases may not be the most economical.

In the case of producer gas, a low grade of fuel may be employed, although in most instances difficulties from caking and clogging are experienced with low-grade fuels, but the process necessarily involves the loss of the heat produced by the combustion of that portion of the fuel used in gasifying the remainder, so that about 30 per cent. of the heat in the fuel is used in the producer. Another feature which must be considered in connection with the use of producer gas in gas engines is the larger size of engine necessary for the production of a given power, as compared with the use of richer gas.

The average calorific power of the various kinds of gas in British thermal units per cubic foot is as follows:

Blast furnace gas	100 B. T. U.
Producer gas, from coke.	135 B. T. U.
Water gas, from coke...	300 B. T. U.
Wood gas, Riché process	340 B. T. U.
Illuminating gas, distilled from gas coal	600 B. T. U.

Leaving out of consideration the illuminating gas, and the water gas, we have for comparison the producer gas and the Riché wood gas, the blast furnace gas being practically a poor grade of producer gas, the utilisation of which depends rather upon problems of purification from dust than from any peculiarity of composition.

M. Lencauchez claims that the Riché gas costs more than it is worth, and calls attention to several points. The retorts require to be heated by fire from without, and the coal consumed to effect the distillation must be charged against the value of the gas produced. The steam which acts to produce the water-gas, is made in the retort itself, which is by no means so efficient a place to generate it as would be a separate boiler. It is claimed also that the charcoal, the value of which is to offset the cost of the gas, is of inferior quality, and of small marketable value.

In the body of the original paper of M. Lencauchez, as well as in the discussions by M. Riché and MM. Manaut and Roman, the details of actual cost and effective power obtained by the use of various kinds of power gas are fully worked out. These computations are too voluminous to be given here but the conclusions of M. Lencauchez are as follows:

	Francs.
Cost of 1 h. p. hour using Riché gas	0.03036
Cost of 1 h. p. hour using steam engine, at 1 kg. coal per h. p. h.....	0.02
Cost of 1 h. p. h. producer gas from Anzin anthracite....	0.0163

Taking these figures to be correct, there seems to be little probability that the Riché gas will ever come into extensive use.

Electric Works in Germany.

In the *Elektrotechnische Zeitschrift* is given the usual annual report of the progress of electric generating stations in Germany for the year, showing the growth which has been made in this important industry, together with some interesting general statistics. The year is closed on the first day of March, after which some time is required for compilation and arrangement, and the full manner in which the results are arranged renders it possible to make some interesting studies.

The work of the year from March 1, 1898 to March 1, 1899 shows great and significant progress. In many places the old works have been found insufficient, and new plants have been constructed, while in others installations have been made where none existed before. The continuous current still hold its place in general favour, more than 80 per cent. of the new plants being of this type. The total number of new installations for 1898-1899 is 114, bringing the grand total of electric generating stations, not including isolated plants, up to 489, as against 375 for the preceding twelve months. In addition to these there are 123 works in course of construction and 15 others about to be built, making 504 works which will be in operation before the close of the current year. Of these establishments 486 have been constructed during the past ten years. The oldest electrical plant in Germany is the Markgrafstrasse station in Berlin, which was built in 1885.

A noticeable feature of many of the modern works is the general use of accumulators for the purpose of equalising the

load. More than 90 per cent. of the continuous-current stations, or nearly 75 per cent. of the whole number, are equipped with storage batteries, these averaging in capacity about 27 per cent. of the generating capacity of the stations.

There has not been a marked increase in the number of stations using alternating or polyphase currents, but the capacity of those already installed has been nearly doubled, while the entire output of all the stations in Germany has been increased by about 50 per cent. over that of last year.

In regard to motive power, steam still holds by far the first place, about 77 per cent. of the whole electrical output being developed from steam power, while 10 per cent. is generated from water power. This proportion is naturally one which is largely governed by geographical and physical considerations, and the proportion would be very different for a mountainous country like Switzerland, and judging from the interest which is at present being taken in this branch of the subject we may expect to find a rapid development of hydraulically generated electrical energy in Italy before very long.

There is, however, in Germany a number of stations employing a mixed source of power, both steam and water power being installed, the former to be used as a reserve in case of failure of the latter. These mixed stations form about 12 per cent. of the whole, the small remaining portion being driven by gas and petroleum motors. The total capacity of the plants at present in operation in the German empire is about 145,000 kilowatts, representing about 200,000 h. p. of mechanical energy.

A Novel Canal Lift.

THE interest which is at present shown in Germany and central Europe generally in the question of internal waterways has caused attention to be given to various details of canal construction, among which is the problem of overcoming differences in level. The delay caused by locks, as well as the limited range of action possible by their use, has caused various plans to be made in order to render it possible to raise and lower the boats through greater vertical distances with less loss of time. Among such devices the hydraulic lifts used at Les Fontinettes in France and La Louvière in Belgium are well known, and the pontoon lift at Henrichenburg, in Germany, is a later device of similar nature.

Several of the plans which have been offered in connection with the proposed canal extensions in Germany involve the use of inclined planes, the boat to be floated into a tank of which the end is then closed and the whole hauled upon suitable tracks up the incline, where the tank is opened and the boat floated out.

A curious and ingenious modification of this inclined plane idea has been devised by Professor Czischek in connection with Herr F. Tentschert, and in a paper by the former in the *Zeitschrift des Oesterr-Ingenieur und Architekten-Vereines* an account of the new method is given.

The peculiarity of the new plan consists in the tank in which the canal boat is conveyed up or down the plane, this being made in the form of a hollow cylinder, open at the ends, and large enough to contain not only the boat, but also a sufficient body of water to enable the latter to float in it. The ends of the cylindrical tank are fitted with heads reducing the circular opening to a smaller diameter than that of the cylinder, a cylinder of 16 metres in internal diameter having end openings of 9.5 metres diameter. When such a cylinder is immersed to its axis in water a canal boat can be floated in, while even when the cylinder is entirely out of the canal there will be enough water retained in it to float the boat.

The boat thus being inside the cylinder, the latter can be rolled up or down an inclined plane in the same manner as a barrel is now handled, the boat floating in the water within and always maintaining its level position. An inclined plane is constructed from the lower canal level to the upper one, the plane being at right angles to the direction of the canal, and so formed that the cylindrical tank can be rolled up to a point slightly higher than the water level of the upper canal and then over the hill down into the water. It will be seen that this device entirely eliminates the necessity of any water-tight gates at the end of the tank, no gates of any kind being needed at all. The boat is simply floated into the open end of the cylinder, and, by means of

rope tackle passing around the exterior it is then slowly rolled up, the excess of water running out of the ends, but enough being retained to float the boat. At the upper level the cylinder rolls up over the hump and down into the water and the boat is floated out, while the reverse operation is performed in lowering.

There are manifest problems to be encountered in the construction of a drum 16 metres in diameter and 70 metres long, and the plans in Professor Czischek's communication show it constructed with twelve longitudinal trussed ribs of two metres depth, thus bringing up the outside diameter to 20 metres, there being hoops at intervals around the ribs, forming tires which roll upon tracks provided for the purpose.

Experiments on the Strength of Glass.

THE extensive use of glass in construction renders definite information about its resistance under various conditions of stress desirable, but with the exception of the ultimate strength under direct compression, but little has been known about the subject until recently.

A series of experiments upon the resistance of glass to tension and to flexure has recently been made by M. Grenet under the auspices of the *Société d'Encouragement pour l'Industrie Nationale,* the details and results being published in the Bulletin of the society. The glass tested was of two varieties, manufactured by the well known works at Saint-Gobain, one being the grade known as No. 4, and the other the so-called "cathedral glass," and there being but little difference betwen the two shown by chemical analysis.

In the flexure tests the specimen was placed as a beam, supported on knife edges and with the load applied in the middle, the weight being a bucket suspended from a cross bar and arranged so that water dropped regularly into it from a separate vessel. The load could thus be applied at a uniform rate without the possibility of shock, and the rate of application kept under perfect control. By applying the usual formula for rectangular beams loaded in the center, the tensile strength per unit of cross section was determined.

The most interesting feature which was developed by these tests was the marked effect produced by variations in the rapidity with which the load was applied. It is well-known that for nearly all materials a rapidly applied load will show an apparent resistance much greater than appears when the stress is applied more slowly, but in the case of these tests upon glass the effect is especially marked. Thus the tensile strength of a number of specimens averaged 6,000 to 7,000 pounds per square inch when the load was applied at a rate which caused the rupture to occur in 15 to 20 minutes, while when the duration of application was increased about three times, so that rupture occurred in about 45 minutes, the strength ranged between 5,000 and 6,000 pounds per square inch. When the water dropping device was arranged for very slow loading, and the breaking load was attained in 10 to 12 hours there was a marked diminution in strength, the resistance per square inch being only about 4,200 pounds.

In order to show the reverse effect some tests were made with loads applied very rapidly, and the effect was most marked, the mean of three trials giving an apparent strength of 10,000 pounds per square inch.

A number of flexure tests were also made by M. Grenet upon glass rods, and these showed the same general results as regards the effect of rapidity of application of load. The actual strength of the rods, however, was higher than that of the plates, which was probably due to the difference in the method of manufacture. Thus when the rupture was produced in about 15 minutes, the strength was nearly 11,000 pounds per square inch, while when the time was extended to 45 minutes the resistance fell to about 9,000 pounds, and for the 12 hour tests the breaking strength was but 5,700 pounds. In order to carry this feature of the tests to an extreme limit M. Grenet suspended various weights to rods and allowed them to remain for a number of days. The result showed that for loads of 3,000 to 3,500 pounds per square inch no rupture occurred even after the expiration of three months, but when the loading was increased to about 4,000 pounds rupture took place in one or two days.

REVIEW OF THE AMERICAN PRESS

The Action of Engine Gases on Bridges.

DURING the recent visit of the American Society of Civil Engineers to the new subway of the Philadelphia and Reading Railway Company, in Philadelphia, attention was drawn to the number of steel girder bridges by which streets are carried across the depressed line of the railway. In connection with the question which was then raised as to the probable action of the gases from the locomotives upon these structures, *Engineering News* discusses the whole subject in an editorial which is well worth reviewing.

The question is really one of much importance, and also one which has by no means received the attention which it demands.

"The corrosive action of locomotive gases is now a matter familiar to every engineer; it is just as certain that these gases will rapidly corrode iron and steel surfaces as it is that sulphuric acid will do it. Is it exactly creditable, then, to the engineering profession to go on putting up expensive steel structures just where they will be exposed to these corrosive agents, and providing them with no better protection than a coat of paint? How much risk is involved in the reduction of sections due to the gradual corrosion? How much does this unknown and unwatched process decrease the factor of safety from year to year?"

The question is not a new one, but it is one of increasing importance, and hence the agitation is most opportune.

"The work of abolishing grade crossings of railways and highways is extending year by year. Every year sees a great number of additions to the list of overhead bridges crossing railway lines. Most of this work is carried out in the most thorough and substantial manner. The public and the corporations which are paying for the work consider and expect it to be permanent, and the engineer ought to spare no pains to insure its permanence. He is not doing this when he calmly puts all his expensive steel-floor system and the bottom chords of girders or trusses into a bath of sulphuric acid and leaves them to certain and rapid destruction."

While this state of affairs certainly does not appear creditable to the engineer, yet there is one reason why it has not earlier been given the attention which it properly demands. That reason is the blind confidence which has been placed in the efficacy of protective paints. The manufacturers of various paints have affirmed that their products were certain protections against the action of corrosive gases, and the engineers, with a confidence worthy of a faith cure victim have proceeded to put painted ironwork where no paint has ever stood or ever will. "As the paint gradually disappeared, some conscientious engineers have repainted and have gone on repainting until the accumulation of coat after coat became too evidently worthless to continue the process longer. Others have resigned themselves to the inevitable and let the rusting go on without attempt at interference."

There are several reasons why no protective paint can be relied upon under such circumstances. In the first place it is practically impossible to insure a perfect continuity of the painted surface, no matter how great care be given to the application of the paint. Even the Bower-Barff process, by which the surface of the metal itself is convered into the rustless and highly resistent magnetic oxide, cannot be so performed as to insure the absence of pin-holes, even when the cleansing action of the sand blast is used to prepare the surface. Beside this we have in the case of the railway crossing the action of the cinder, ash, and sparks discharged by the locomotives, to cut through any protective paint, however good, and expose the metal to the action of the corrosive gases.

It will not do for the engineer to plead that he has done the best in his power when he has placed a steel or iron girder across a railway track and given it a few coats of a commercial protective paint. There are

other and better constructions and the competent engineer knows them all. The brick or masonry arch is by no means obsolete, and indeed there has been of late in many quarters a decided tendency to revive this ancient, honorable, and wholly valuable form of construction. The arch has lived a long and useful life and is by no means yet dead. Indeed it has recently taken a new and vigorous lease of life in connection with the so-called "reinforced concrete" construction, and there is every reason to believe that flat arches constructed on the Mornier or Melan principle, with steel structure entirely imbedded in concrete, would serve most effectively for railway crossings where contact with sulphurous gases is inevitable.

The opinion held by many from the first, is being confirmed by growing experience, that steel or iron structural work, wholly imbedded in concrete, is altogether free from deterioration by corrosion. The iron work of the old Palais d'Industrie, which stood on the Champs Elysées from 1862 until 1898, revealed no evidence of corrosion of its imbedded iron work when it was demolished, and other examples in the United States have confirmed this experience. The whole question is one of oversight and misplaced confidence, and while much reckless work has already been done in placing important structures where they are certain to be destroyed by corrosion in a few years it is not too late to take warning for the future, and to avoid such negligence in the future.

An Automobile Association.

WITH the increasing use of motor vehicles has come a realization of the opposition which must be expected in some quarters to the innovation. The bicycle rider had to fight his right of way, so to speak, not so very many years ago, and the owner or driver of the motor vehicle finds himself in much the same position to-day. It is apparent that such opposition can be only temporary, but it will be overcome much sooner by concerted action than in any other manner, and with this end in view the *Electrical Review* proposes the formation of a national automobile association to accomplish in the United States what the Automobile Club has done in France.

"To-day the self-propelled vehicle—whether electromobile or oil driven, or other machine for country use—stands in the same position that the electric light and the electric street railway occupied in 1884 and 1887, respectively; its coming is opportune and its future big with promise, but its novelty and unfamiliarity work to its disadvantage."

Instead of waiting for the slower influence of public opinion it is suggested that a strong association, consisting not only of owners and users, but also of makers and inventors, be formed to insist upon the rights of such vehicles to the roads and parks under the same conditions as already exist for other vehicles, and that unfair and prejudiced discrimination be handled in the same manner as any other form of injustice.

"There seems to have been recently a wave of municipal opposition to automobiles, and the commissions in charge of parks in several large cities have been compelled to suffer the discipline of the courts before they would see reason. There are many interests which are in apparent conflict with those of automobilists, and it is not to be doubted that certain classes of horsemen will endeavor to assail both the popularity and the development of the automobile in every possible way. There is need, therefore, both for legislation and wisest municipal regulation, and also for missionary work to be done with the press and among the general public. To the large majority of the latter the automobile is still a curiosity. To familiarize them with the machine, to teach them the immense and wide-reaching advantages that will follow its general use, to popularize the automobile so as to create among the masses of people a demand for such vehicles, resulting naturally in cheapening and bettering their construction, will be a few among the many good works which the association that has been outlined can perform.

"All these things are now being undertaken by various users and makers of automobiles, and by small societies of only local extent in various parts of the United States and Canada. If the effort that is thus diffused can be properly concentrated, the effectiveness of the work done will be

vastly enhanced, and results will be obtained with far less trouble and expense. The concentration of effort will give to a strong general organization the ability to employ the highest grade of legal talent to present its case with far more impressive strength, to interest the public to a greater degree through its stronger hold upon the press, and also to discover the majority view of automobilists upon the many questions which are still under discussion among them."

That such an organization would be for the general good of the community cannot be doubted. The wide use of motor vehicles, especially in large cities, will certainly be attended with greater cleanliness and freedom from the offensive filth which is involved in the presence of the horse, while the removal of stables will take away the main breeding place of flies and other disseminators of disease. The highway capacity of the crowded streets will be more than doubled, and the general use of smooth impervious pavements will be everywhere possible. That the introduction of such advantages, among many others, should be retarded and hindered by the obstinate prejudice of a few should not be permitted, and if the organization of a powerful association with all the influence which comes with numbers, information, legal support and counsel, and ample funds, can hasten the day of the automobile, by all means let such an organization be promptly formed and effectively supported throughout the United States and Canada.

Engineering Expeditions.

THE work of the civil and mining engineer often requires him to live away from civilization for months at a time, and unless he knows how to camp out and to keep himself and his party in good working condition under such circumstances, much time and effort may be lost.

In an excellent paper upon the equipment of camps and expeditions, Professor Charles H. Snow gave the American Institute of Mining Engineers some useful information in this line of work.

"The engineer has often to penetrate difficult or unknown regions. Mineral, irrigation, boundary, and railway problems frequently necessitate journeys through, or long residence in localities whence sustenance cannot be drawn. The selection and conveyance of provisions, outfit and implements thus become a matter of first importance. Scientific skill, even of the highest order, is powerless unless supported by the proper appliances and foods. The advance of civilization favors the engineer, in that it is constantly enlarging his facilities and thus reducing his difficulties."

Taking up the subject in a systematic manner, Professor Snow considers successively transportation, food, packing, shelter, clothing, miscellaneous implements, instruments, personnel, and medicines, the last including camp hygiene.

Transportation is so much a local matter that it can be treated only in the broadest manner, but some excellent points from actual practice are given, among them being the not unnecessary hint that the native methods of a locality may be based on experience which it would not be wise to ignore.

Food is a matter about which much has been said of late in connection with military experience, and Professor Snow emphasizes the necessity of variety, if the food is to continue palatable and digestible. Such foods as must be used in expeditions are naturally deficient in nourishing power, and hence there is all the greater necessity for assisting digestion. This whole subject, including the so-called "emergency foods" is discussed at much length in the paper, and this portion is a valuable contribution to explorers as well as to engineers. A table of suggestions as to food combinations, with proportions and nourishing values is given for use in preparing an outfit.

While the instruments of a party must be largely determined by the nature of the work to be performed, yet there are some notes on the subject which are of general interest. Apart from the actual work of the expedition every member should be provided with a compass and should understand the art of tracing his way through forest or swamp. Several aneroids should be carried and observations made simultaneously when possible, in order to check the instruments and compare errors, and often data gained from the rough observations of explorers acquire a vast importance in boundary and

other disputes. A camera should always be carried, and with the compact instruments and films now made there is no reason why a full photographic record of an expedition should not be made in nearly every case.

The question of health is very important, and while there is no occasion for an elaborate medical outfit to be carried there are certain remedies and appliances which ought to form a portion of every equipment. Such an outfit is tabulated by Professor Snow with notes upon the uses of the various medicines and brief instructions as to the proper help to render in emergencies, and in the absence of a doctor, such instructions ought to be in the hands of every one.

The routine of camp hygiene should be drilled into every member of the party, since neglect of proper precautions by one may endanger the health of all the others and render all care useless.

As a summary, not only of his own experience, but also of that of many other engineers and explorers, Professor Snow's paper must be regarded as a most valuable contribution to the practical side of engineering, and had such methods as he emphasizes been enforced in all cases in the past there would have been success in many instances where failure has occurred.

Electric Delivery Wagons.

An early application of the electrically propelled vehicle was its employment by the large department stores for delivery of purchases to customers. At first this use was doubtless prompted by a desire to turn the interest in the novel vehicles to advertising purposes, but experience has revealed the superiority of the motor delivery wagon over that drawn by horses. In a paper presented at the recent meeting of the American Institute of Electrical Engineers, Messrs. Sever and Fliess gave some interesting and valuable data concerning the actual operative costs of electrical delivery wagons.

A careful investigation of the amount of work done by delivery wagons hauled by horses shows that the work performed by a horse is 0.89 of a standard horse-power of 33,000 foot pounds per minute. Also that the cost per day for 2 horses, 1 driver and 1 boy is $4.28.

In comparison with these figures, the data for automobiles were obtained from actual tests made in New York City, under varying conditions of grade and pavement, and in all kinds of weather, taking the readings from the volt and ampere meters. Data for a number of tests were given in the paper, and at the average speed of 10.5 miles per hour the power required was found to be 105 watt-hours per ton-mile, but in order to be on the safe side the rate was taken at 120 watt-hours per ton-mile, and this was the basis upon which the comparative costs of the electric and horse-drawn vehicles were computed. Making allowance for interest on the cost of the wagon, and taking all expenses into account, the cost per day for the electric delivery wagon is shown to be $3.87 per day, a decided economy over the horse-drawn vehicle.

Apart from the mere operative economy in favor of the electric vehicle there are other important advantages. When not in operation, as on Sundays and holidays, no energy is consumed, while the cost of care and feed of horses continues whether any returns are made or not. The advantages of cleanliness and convenience have been enlarged upon elsewhere, but should never be lost sight of, while for the present at least, and until such vehicles become common the advertising element is unquestioned.

The real question of operative economy depends upon the price which must be paid for power, and this at the present time is a variable factor. As such vehicles come into general use they may become a valuable means of equalizing the load upon the power stations and by being charged at hours when the outside load is light they may be able to obtain very favorable terms. "Owing to the regular nature of the work imposed upon the wagons in delivery service it could easily be arranged to have the electric vehicles charged at night after the heavy load is off the station. They might also be charged early in the morning and at noon, or at periods which experience would indicate as most advantageous for the station, the time of deliveries being adjusted to suit the new conditions. In this way a stable should be able to buy power at from 1 to 2 cents per kw.-hour."

In general the conclusions from this valuable paper are:

"In light delivery service in large cities, when a number of units are employed by different firms, the adoption of the automobile would seem to be merely a question of time. For this kind of service it seems to be eminently the best solution. It is cheaper to operate than the horse service, and the mechanical problems have been so far solved as to make the vehicles commercially successful. Though it is not the intention to discuss depreciation, it may be noted that the comparison of the costs of operation as regards food, cost of power, etc., would show a saving in favor of the electric delivery wagon, in one year of 20 per cent., which under more favorable conditions as to the price of power, might easily be increased. Assuming, for the moment, that the depreciation in a year is 25 per cent. for the electric system, and, under the same service conditions, is only 10 per cent. for horse traction, we still have a saving of 5 per cent. in favor of the automobile."

Cooling Towers.

THE advantages of condensing engines are now so generally appreciated that in many places where an insufficient water supply is available attempts are made to obtain good results with a much smaller quantity of water than was formerly supposed possible.

Evaporative condensers have been installed in some places, but the more general plan is to cool the water after it has been once used and employ it over and over again, depending upon the local supply only to provide for the waste. Various methods have been adopted for this purpose, the oldest device being a shallow pond through which the water is made to circulate by partitions in such a manner that much of the heat is abstracted by contact with the air. In other cases the water from the hot well is discharged in spray, thus bringing it into intimate contact with the air, and the cooled drops collected in a pool for repeated use.

Of late the device known as the cooling tower has been employed, and various forms of this apparatus have been devised. In principle they are much alike. Water is delivered to the top of a tower and allowed to descend in drops, films or other broken form while at the same time a current of air is caused to move in the opposite direction at a considerable speed, and when the proper proportions are observed the water which reaches the tank at the bottom is sufficiently cooled to be available for use again in the condenser.

A mathematical discussion of the theory of such cooling towers is given in a paper by Mr. W. A. Mosscrop in a recent issue of *Engineering News*, and while it is not practicable to review the treatment in detail some of the essential features for successful design may be brought out here.

The real causes of cooling in a tower such as has been described above are; cooling by the evaporation of a portion of the water; and cooling by contact of the water with the air. To these may be added the cooling by contact with the walls of the tower, but this is an element so small that it may be neglected.

The degree of cooling which may be obtained by evaporation of moisture in free air is dependent upon the relative humidity of the atmosphere, that is, upon the amount of moisture already in it. This is well seen in the wet-and-dry-bulb thermometer, in which two thermometers are exposed, one with the bulb covered with moistened cotton, the other uncovered. The evaporation from the covered wet bulb produces a reduction in temperature, and from the difference in the readings of the two thermometers the amount of moisture in the air may be computed. No matter how diligently the wet bulb be fanned, or exposed to air currents the temperature will not fall below a definite point, dependent upon the relative humidity of the air at the time. In a dry climate like that of Colorado the reduction may be as much as 30 degrees or more, while in the moist air of the sea coast it may be only a few degrees. At the same time the velocity of the air current enters into the computation of the capacity of the cooling tower, as the moist air produced by the evaporation must be carried away immediately and replaced by fresh or the evaporation will soon cease. The cooling by contact with the air depends mainly upon the extent of surface exposed, and upon the difference in temperature, and from

these elements formulas may be deduced. At the present time there is a lack of experimental data upon which some of the constants in the formulas are based, but with the interest which is being given to the subject additional information upon these points should soon be available. At the present time, however, some suggestions upon the construction of cooling towers may be made.

Since the greatest source of cooling is the evaporation of a portion of the water, such towers will certainly be most effective at high altitudes and in dry climates, and these conditions obtain where water is scarce and where cooling towers are likely to be installed. Since the evaporation must take place from the surface of the water to be cooled it should be exposed to the action of the air in films, giving as great an extent of surface as possible, and breaking up and agitating the water as little as possible. Since the production of the air current requires power, it need not be given a greater velocity than is necessary to remove the moisture as rapidly as it is formed, and by observing wet and dry bulb thermometers suitably placed, the condition of the incoming and discharge air can be ascertained very readily. If the two bulbs in the discharged air stand at the same point the air is saturated, while the difference between them in the incoming air shows the maximum degree of cooling which may be attained. With ample means of obtaining information, based upon experience under various climatic conditions there appears to be no good reason why such cooling towers may not be proportioned as definitely as any other part of the power plant to which they belong.

Politics and Engineering.

It is one of the misfortunes which attends the execution of most great public works that engineering and politics cannot be separated, and that the skill and ability of the engineer is often confounded by the ignorance and incapacity, to call it by no worse name, of the politician. This is not only true of isolated cases, but is also an unfortunate feature of the conduct of those permanent engineering departments upon which the health and safety of large cities mainly depend.

In a recent issue of *Municipal Affairs* an article treating of this subject appears under the title of "A Tale of Two Cities," the concrete subject being the water supply question in London and in Philadelphia.

The comparison is interesting for several reasons, one among them being the fact that in London there are a number of private companies, while in Philadelphia the water works are owned and operated by the municipality, with a hungry corporation waiting in the background to capture them when possible.

Another interesting comparison between the two cases appears in the fact that in London the per capita consumption is the smallest of all in a table of many large cities, while in Philadelphia the amount supplied per head is the next to the top of the list. In London the supply is 37 gallons per head per day, while in Philadelphia it is 166.15 gallons!

Two things result from this state of affairs. In London there is an outcry against the insufficient supply, while in Philadelphia there is a demand for the reduction of waste in order that a purer article may be supplied. Since the charges in London are based, not upon the supply but upon the property valuation, there is naturally much objection to the meagreness of the supply.

"The complaint against the water companies is not only that there is no competition, that the plants are overcapitalized, that the rates are excessive, and that the charges are increasing annually without a corresponding increase in the character of the service but that the supply is entirely inadequate. Every year, as certain as the warm weather of the summer months comes, there is a water famine in East London which affects one-fourth the population of the city. Beginning in August, it lasts until October or December, and during these months the water supply is often shut off eighteen or twenty hours out of the twenty-four, and each person is obliged to store what water he wishes to use in jars, pans, etc. Such a course is impracticable mong the poorer classes—those who most need an abundant supply for sanitary purposes. Then, too, the quality of the water is such that after it has stood some time it becomes positively distasteful and its stale odor is extremely disagreeable.

"So great is the famine that the public authorities loan thousands of jars and pans to the people, and even undertake to furnish a very limited supply of water from carts. The first city in the world, with a people noted for its great industrial ability, is thus dependent upon the primitive methods of water carriers for what is everywhere recognized to be one of the first essentials of civilization."

Turning now to Philadelphia there is another story none the less discreditable. Water there is, but it is foul with disease and the germs of death. The Schuylkill, from which the supply is derived, is practically an open sewer, and the demand for water which the excessive waste has created renders it necessary that this foul stuff must be pumped directly into the mains, the capacity of the plant not permitting opportunity for subsidence, much less filtration. As a result Philadelphia, from being one of the most healthful cities in the United States, has now a typhoid fever death rate which gives it an unenviable prominence among all the great cities of the world. "From January 1 to May 10, 1899, there were over 6,000 cases of typhoid fever reported to the Board of Health, and 677 deaths. Should the death rate for the remainder of the year fall to normal, there would be at least 900 deaths from typhoid alone—the abnormal death rate of over 70 per 100,000; a rate that is exceeded in very few civilized cities in the world and which is far above that of nearly all American and European cities."

Philadelphia is preparing at the present time to open a great exposition, but with this prospect before them one is led to question the advisability of placing such a state of affairs on public exhibition.

This condition of affairs is altogether the result of the interference of the politician with the work of the engineer. Philadelphia has at the head of its Bureau of Water one of the ablest and best-known engineers in the United States, Mr. John C. Trautwine, Jr., and his able and fearless reports have shown how well he understands the subject. His hands have been tied and his recommendations ignored. The evidence of waste has been neglected, and the only method by which filtration can be secured, *i. e.*, the introduction of meters to bring the quantity of water to be treated within practicable limits, has been opposed by the politicians.

In order to show how little the magnitude of the problem is realized it may suffice to know that the present chief magistrate of the city before taking his seat said: "I propose to study the water question from begining to end. When I have thoroughly mastered all points I will decide on the plan which I think is best. *I expect to devote the greater part of the next ten days to the subject.*" The italics are ours. Truly he had the courage of his ignorance.

When politicians undertake to do in ten days what no competent engineer would venture to attempt, with all his previous training, for many months, surely it is time for the people of the fever stricken city to act.

Water-Power Governing.

WITH the extensive utilization of hydraulic power for the generation of electricity there has arisen a demand for more accurate speed regulation than was formerly deemed necessary. In this respect there is a marked analogy to the improvement in the government of steam engines which was brought about by the development of electric lighting. Water wheel governing however, involves a number of more difficult problems than those which appear in steam engine governing, and this side of the subject formed the theme of a paper before the American Institute of Electrical Engineers, by Mr. A. V. Garratt.

In the case of steam it is only necessary to vary either the steam inlet or the point of cut-off and the speed promptly responds. With water power, and especially with the modern high pressure wheels, we have to deal not with a light, elastic fluid, but with a heavy, incompressible material, and problems of inertia must be dealt with. Not only is there a large mass of moving water, but there are also gates having weight and frictional resistance, and the momentum and inertia of these elements form matters which demand consideration. When, as is not infrequently the case, a large portion of the load is suddenly thrown off a wheel operating at full gate a great amount of energy must be absorbed, and the extent to which this is sometimes the

case is shown by a numerical example. It is, of course, desirable to keep the pressure constant on a wheel, but in practice this is found to be impossible. Remedies which have been used to help meet this point are, the use of relief valves near the wheel case, so arranged that they will open when the proper static head is exceeded, or standpipes. When it is especially desired that sudden changes of load should not materially affect the speed, a standpipe is a valuable auxiliary, and in some instances fly wheels are also used. With the modern hydraulic and electric power plants, however, there is rarely any need of fly wheels, since the various rotating parts, including the wheel itself, the armature, pulleys, etc., have a sufficient moment of inertia and angular velocity to enable a first-class governor to hold the speed within satisfactory limits.

The use of the draft-tube must be considered in connection with speed regulation, and it is not advisable to use the full length which may be available, since the atmospheric pressure may produce a water-hammer effect if the wheel is suddenly shut down. The draft-tube, if used, should be short and as nearly vertical as possible, while the greater the angle of descent given to the water in the flume the better for purposes of regulation.

When a plant has not been well-designed from a hydraulic point of view it may sometimes be improved by the application of fly wheels, so arranged as to absorb the energy and give it out again before the changes can reach the wheel, but it is often better to correct the design of the plant and install good governing devices.

While reliable governors are doubtless most important appliances, the question of speed regulation may also be considered in another light, *i. e.*, in connection with prevention rather than cure. Instead of atempting to adjust the power to every sudden change in load, every effort should be made to equalize the load itself. Just as the hydraulic stand-pipe has been used to equalize the water pressure, so the storage battery may be used to equalize the demand upon the wheels. When a wheel is operated under a fairly constant head and the plant is provided with storage capacity sufficient to equalize the demands which may come for power, we have a form of fly-wheel which should materially simplify the problems in connection with the speed regulation of hydraulic power plants.

THE ENGINEERING INDEX

INTRODUCTORY.

The object of this Index is to supply all persons interested in engineering and industrial pursuits with, first, an expert descriptive summary clearly indicating the character and purpose of the leading articles published currently in the established technical journals of the United States, Great Britain, and the Continent—in all languages; and, secondly, an inexpensive means of readily obtaining such portions of this literature as may be desired.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed, *in the original language*; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20c. The letter A, B, or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; and H, of $1.60. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the Index are: Ill—Illustrated; W—Words; Anon—Anonymous.

American Architect. *w.* Boston, U. S. A.
American Electrician. *m.* New York.
Am. Engineer and Railroad Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, U. S. A.
American Journal of Science. *m.* New Haven, Conn.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. *w.* Pittsburg.
American Shipbuilder. *w.* New York.
Am. Soc. of Irrigation Engineers. *qr.* Denver
Annales des Ponts et Chaussées. *m.* Paris.
Architect. *w.* London.
Architectural Record. *q.* New York.
Architectural Review. *s-q.* Boston, U. S. A.
Architecture and Building. *w.* New York.
Architektonische Rundschau. *m.* Stuttgart.
Australian Mining Standard. *w.* Sydney.
Automotor and Horseless Vehicle Jour. *m.* London.
Berg-und Hüttenmännische Zeitung. *w.* Berlin.
Brick Builder. *m.* Boston, Mass.
Bridges. *m.* Chicago.
British Architect. *w.* London.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Phila.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin of the Univ. of Wisconsin, Madison, U.S.A.
Bull. Int. Railway Congress. *m.* Brussels.
California Architect. *m.* San Francisco.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Dingler's Polytechnisches Journal. *w.* Stuttgart.
Domestic Engineering. *m.* Chicago.
Eclairage Electrique. *w.* Paris.
Electrical Engineer. *w.* London.
Electrical Engineering. *m.* Chicago, Ill.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Elektrochemische Rundschau. *b-m.* Frankfurt.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnisches Echo. *w.* Magdeburg.
Electrotechniker. *b-m.* Vienna.

Elektrotechnischer Anzeiger. *s-w.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita, *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering Assn. of the South. Nashville, U.S A.
Engineering and Mining Journal. *w.* New York.
Engineering Journal. *s. an.* Stanford Univ., Cal.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of the School of Prac. Sci. Toronto.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, U.S.A.
Fire and Water. *w.* New York.
Foundry. *m.* Detroit,
Gas Engineers' Mag. *m.* Birmingham,
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e d. Str. Ferr. *w.* Rome.
Glaser's Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating. *m.* New York.
Horseless Age. *w.* New York
Ice and Refrigeration. *m.* New York.
Ill. Carpenter and Builder. *w.* London.
Illinois Soc. of Engs and Surveyors. Peoria, U.S.A.
India Rubber World. *m.* New York.
Indian and Eastern Engineer. *m.* Calcutta.
Industries and Iron. *w.* London.
Inland Architect. *m.* Chicago.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Jour. Am. Soc. Naval Engineers. *qr.* Wash., D. C.
Journal Assn. Eng. Societies. *m.* Phila., Pa.
Journal of Electricity. *m* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Jour. N. E. Waterw. Assoc. *qr.* New London, Conn.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, Va.
Journal Western Soc. of Eng. *b-m.* Chicago, Ill.
Journal of Worcester Pol. Inst. Worcester, Mass.
Kansas University Quarterly. *qr.* Lawrence, Kans.
La Ingenieria. *m.* Buenos Aires, Argentina.
L'Energie Electrique. *w.* Paris.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Marine Engineer. *m.* London.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Master Steam Fitter. *m.* Chicago.
Mechanical World. *w.* London.
Mechanical Engineer. *w.* Manchester.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco, U.S.A.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d. Kgl. Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Moniteur des Architectes. *m.* Paris.
Moniteur Industriel. *w.* Paris.
Municipal Affairs. *qr.* New York.
Municipal Engineering. *m.* Indianapolis, U. S. A.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nature. *w.* Paris.
New Zealand Mines Record. *m.* Wellington, N. Z.
Nineteenth Century. *m.* London.
Oest. Monatsschr. f. d. Oeff. Baudienst. *m.* Vienna.
Oest. Zeitschr. f. Berg- & Hüttenwesen *w.* Vienna
Ores and Metals. *w.* Denver, Colo.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York
Proceedings Engineers' Club. *qr.* Phila.
Proceedings of Central Railway Club.
Pro. of Purdue Soc. of C. E. *yr.* La Fayette, U.S.A.
Progressive Age. *s-m.* New York.
Railroad Car Journal. *m.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway Magazine. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Railway World. *m.* London.
Review of Reviews. *m.* New York.
Revista de Obras Públicas. *w.* Madrid.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Marittima. *m.* Rome.
Sanitarian. *m.* Brooklyn, U. S. A.
Sanitary Plumber. *s-m.* New York.
School of Mines Quarterly. New York.
Schweizerische Bauzeitung. *w.* Zürich
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Seaboard. *w.* New York.
Sibley Journal of Eng. *m.* Ithaca, U. S A.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Indicator. *qr.* Hoboken, U. S. A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago, Ill.
Technology Quarterly. Boston.
Terrestrial Magnetism. *qr.* Cincinnati, O.
Trans. Assn. C. E. of Cornell Univ. Ithaca, U. S. A.
Trans. Am. Ins. Electrical Eng. *m.* w York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. of Civil Engineers. *m.* New York.
Trans. Am. Soc. of Heat. & Ven. Engrs. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Transport. *w.* London.
Western Electrician. *w.* Chicago.
Western Railway Club Pro. Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Wisconsin Engineer. *qr.* Madison, Wis.
Yale Scientific Monthly. *m.* New Haven, U. S. A.
Year Book of Soc. of Engs. Univ. of Minn.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutcher Ingen. *w.* Berlin.
Zeitschrift für Elektrochemie. *s-m.* Halle a. S.
Zeitschrift für Elektrotechnik. *s-m.* Halle a. S.

ARCHITECTURAL ENGINEERING

CONSTRUCTION.

Bridge Architecture.

See Civil Engineering, Bridges.

Convention Hall.

The Kansas City Convention Hall. Illustrated description of a hall seating 25,000 people, in which some of the galleries are suspended from roof trusses of 187 ft. span. 1500 w. Eng Rec—July 22, 1899. No. 28683.

Cyclorama.

The Cyclorama Building in the Prater at Vienna (Rundgemälde-Gebäude un Prater in Wien). Oskar Marmorek. With view of entrance, and plan on section showing details of construction. 1000 w. Wiener Bauindustrie Zeitung—July 6, 1899. No. 28774 B.

Exposition.

The Building of Mines and Metallurgy (Palais des Mines et de la Métallurgie). René Weil. A description of the building now under construction for the Paris Exposition, with plans and views of the present state of the work. The computation of the stresses on the frames is given. 3500 w. 1 plate. Génie Civil—July 1, 1899. No. 28704 D.

Fireproofing.

Scagliol and Petrura. Information relating to two fire-resisting materials being introduced in London. 700 w. Builder—July 8, 1899. No. 28621 A.

Test of Wide Floor Arches. Corydon T. Purdy. Gives an illustrated description of a test of two 7 ft. arches, one segmental and the other flat. 1200 w. Br Build—July, 1899. No. 28813 C.

Hospital.

Engineering Features in the Alexian Brothers' Hospital, Chicago. Description with illustrations, of a hospital where all the arrangements are on sanitary principles. 1800 w. Eng News—July 20, 1899. No. 28675.

Reinforced Concrete.

Groined Steel Roof Arches. Illustrated description of gothic arches made of steel shapes bent by special machines, which are explained, and covered with concrete to give the effect of solid masonry. 600 w. Eng Rec—July 8, 1899. No. 28519.

Schools.

The Planning and Construction of Board Schools. T. J. Bailey. An account of the building work of the London School Board, discussing sites, buildings, warming and ventilation, etc. Ill. Discussion. 1200 w. Jour Roy Inst of Brit Archts—June 3, 1899. No. 28589 B.

Stability.

The Effect of Bell Ringing on the Stability of Towers (Beobachtung von Thurmschwingungen beim Läuten der Glocken). J. Bürgin. Giving data and results of micrometric measurements upon a tower in which heavy bells were rung. Two articles, 3000 w. Deutsche Bauzeitung—June 28, 30, 1899. No. 28775 each B.

Stables.

Two Noteworthy New York Stables. Illustrated description of the construction and architectural fittings of the stables of H. O. Havemeyer, and O. H. Payne. 3200 w. Eng Rec—July 15, 1899. No. 28598.

Vienna.

Foundation Work in Vienna (Ueber die Fundirungsverhältnisse in Wien). Ferd. Dehm. An elaborate account of the strata underlying the city of Vienna with regard to the construction of building foundations. 7500 w. Zeitschr d Oesterr Ing u Arch Ver—June 23, 1899. No. 28727 B.

HEATING AND VENTILATION.

Fans.

The Calculation of Centrifugal Fans for Ventilating Purposes. H. Eisert. Read at the Saratoga meeting of the Am. Soc. of Heat. & Ven. Engs. An account of the investigations of the writer. 5000 w. Heat & Ven—July, 1899. No. 28809.

Hospital Heating.

A Hospital Central Heating Plant. Illustrated description of a central power house and heating plant for the Bellevue Hospital, New York. 1300 w. Eng Rec—July 22, 1899. No. 28686.

Hot Water System.

A Combined Direct and Indirect Hot Water System. Plans of the building are given with description of a successful heating plant. Two other plants proved unsuccessful. 800 w. Met Work—July 15, 1899. No. 28591.

Paris Exposition.

Description of Arrangement for Heating and Ventilating Exhibit at Paris Exposition, 1900. W. F. Wolfe. Read at the Saratoga meeting of the Am. Soc. of Heat & Ven. Engs. Information regarding space, classification, attendance, etc. 2000 w. Heat & Ven—July, 1899. No. 28810.

Steam Conduits.

Steam Pipe Conduits and the Distribution of Steam to Scattered Buildings. An editorial discussion of the best types of construction with an accompanying illustrated article on the system at Dartmouth College. 2100 w. Eng Rec—July 8, 1899. No. 28512.

Steam Heating.

Heating with Steam at or Below Atmospheric Pressure. J. H. Kinealy. Read at Saratoga meeting of the Am. Soc. of Heat. & Ven. Engs. Describes investigations made and conclusions reached. 6500 w. Heat & Ven—July, 1899. No. 28811.

Tall Buildings.

Some Points Regarding the Ventilation and Heating of Tall Buildings. Henry C. Meyer, Jr. Discusses various types of apparatus used. 2500 w. Dom Engng—July, 1899. No. 28652 C.

PLUMBING AND GAS FITTING.

Club House.

Plumbing in the New York Athletic Club House. Illustrated description of noteworthy work, including a special form of mechanical filter. 2400 w. Eng Rec—July 29, 1899. No. 28839.

Leaks.

Leaks in Plumbing Work. Alex. W. Murray. Considers leaks in connections beneath the surface of the ground, or under basement floors, and how to protect and repair them. Ill. 2500 w. Dom Engng—July, 1899. No. 28651 C.

MISCELLANY.

Building Inspection.

The Building Department of Boston, Mass. A statement of the results of an investigation by a special committee representing the local master builders, fire underwriters, architects and real estate dealers, into the manner in which the building laws of Boston are enforced. 2300 w. Eng Rec—July 8, 1899. No. 28511.

Mechanical Plant.

The Mechanical Plant of the Park Row Building, New York. Describes the engine, boiler, dynamo, elevator, ventilating and heating plant in a building 390 feet high and having 8 acres of floor surface. Many of the features are novel. Ill. 3000 w. Eng Rec—July 1, 1899. No. 28445.

Timber.

Timber and Timber Structures. T. Roger Smith. A lecture delivered at Carpenter's Hall, London. Deals with its preparation and care as a material of carpentry and joinery, and its use in the construction of buildings. 7000 w. Builder—June 24, 1899. No. 28426 A.

CIVIL ENGINEERING

[BRIDGES.

Alexander III.

The Alexander III. Bridge. Brief illustrated description of the work and of the processes adopted in its erection. 1800 w. Engng—July 14, 1899. Serial. 1st part. No. 28694 A.

The Alexander III. Bridge Over the Seine (Pont Alexandre III. sur la Seine). E. Rouyer. Especially devoted to the construction of the false-work truss and the erection of the arch ribs. 2000 w. 1 plate. Génie Civil—July 8, 1899. No. 28705 D.

Arch.

A Stone Arch Rib Railroad Bridge. Illustrated description of three 60-ft. masonry spans, each consisting of a pair of masonry ribs placed side by side like trusses. 500 w. Eng Rec—July 8, 1899. No. 28513.

The Forbes Street Bridge, Pittsburg, Pa. Illustrated description of an old and a new arch bridge of about 150 ft. span, showing the development of structural work of this type in the last 25 years. 2500 w. Eng Rec—July 15, 1899. No. 28593.

Bridge Architecture.

The Architectural Element in Engineering Works. H. Heathcote Statham. Discusses various types of bridge architecture showing the attention given to this branch of engineering, especially during the 19th century. 12200 w. Jour Roy Inst of Brit Archts—May 20, 1899. No. 28476 B.

Cantilever.

Cantilever Bridge at Lewiston, Idaho. Illustrates and describes a recently completed bridge of considerable interest from an engineering standpoint. 1100 w. Ry & Eng Rev—July 8, 1899. No. 28533.

Corrosion.

The Protection of Overhead Bridges from Locomotive Gases. Editorial discussion of this subject and the need of reform in engineering practice, with sug-

gestions for remedying the trouble. 1500 w. Eng News—July 20, 1899. No. 28677.

Drawbridge.

Replacing the Newark Draw. Illustrated description of the method employed to replace a 400-ton draw span with one of 600 tons, with a minimum interference with river and rail traffic. 1700 w. Eng Rec—July 29, 1899. No. 28838.

Erection.

The Erection of Iron Bridges in America (Die Aufstellung Eiserner-Brücken in Amerika). Carl Bernhard. A description of the rapid methods of erection used by the American builders of iron bridges. Two articles, 7000 w. Zeitschr d Ver Deutscher Ing—July 8, 15, 1899. No. 28724 D.

French Bridges.

Notes on Recent French Bridge Construction. Notes and illustrations explaining details of interesting structures of recent date. 1500 w. Eng News—July 6, 1899. No. 28457.

Stone Bridges.

Stone Masonry Bridges. Extracts from a paper by Mr. Owen Morris. Brief notes both historical and descriptive. 1400 w. Stone—July, 1899. No. 28823 C.

CONSTRUCTION.

Reinforced Concrete.

Test of a Concrete-Iron Girder (Probebelastung einer Gurtträgerbrücke). M. Möller. Details of tests of reinforced concrete beam of 15 metres span, loaded uniformly to destruction, with photographs of the structure before and after testing. 1200 w. Deutsche Bauzeitung—July 5, 1899. No. 28776 B.

See Architectural Engineering, Construction.

Roads.

Roads: Their Construction and Maintenance. Part first considers the nature of the materials available, their merits and disadvantages. 2000 w. Builder—July 1, 1899. Serial. 1st part. No. 28542 A.

The Work of General Gallieni in Madagascar. From *Le Monde Illustre*. An account of road construction on the Indian Ocean side of the island, which will in time be mentioned as one of the most beautiful roads in the world. Ill. 900 w. Sci Am Sup—July 8, 1899. No. 28449.

Shed Extension.

See Railway Affairs, Permanent Way.

Steel Pier.

The Atlantic City Steel Pier. Illustrated description of a structure 1,600 ft. long and 40 to 120 ft. wide, carried on shoe piles of novel form. 1700 w. Eng Rec—July 1, 1899. No. 28441.

Tunnels.

Notes on Tunneling. Abstract of remarks by Sir Benjamin Baker on the behavior of earth through which tunnels are driven. 1300 w. Eng Rec—July 8, 1899. No. 28518.

The Irish Channel Tunnel Scheme. Editorial on the scheme to construct a tunnel between Scotland and Ireland. 1600 w. Engr, Lond—July 14, 1899. No. 28699 A.

The North Bessemer Tunnel. F. E. House. Read before the Engs.' Soc. of W. Penna. Describes the construction and the causes for change of plans. 2200 w. R R Gaz—July 7, 1899. No. 28500 W.

The Work on the Simplon Tunnel (I Lavori del Sempione). Pietro Biraghi. A discussion of the quarterly report of the work both at the north and south ends, and a description of the power plants at each entrance. Three articles, 5000 w. Rivista Gen del Ferrovie—May 7, 15, 21, 1899. No. 28773 each B.

HYDRAULIC AND MARINE.

Breakwaters.

The Delaware Breakwater. Condensed from report of C. W. Raymond. Illustrated description of a random-stone breakwater which departs in many respects from the accepted practice based on the Cherbourg breakwater. 2200 w. Eng Rec—July 8, 1899. No. 28517.

Canal.

The Latest Plans for the Panama Canal (Des Panama-Canal nach dem Neuesten Entwurfe). A review of the report of the Technical Commission upon the Panama Canal, showing the cost of completion and the general condition of the work. 4000 w. Zeitschr d Oesterr Ing u Arch Ver—June 30, 1899. No. 28728 B.

The Rhine-Elbe Canal (Der Rhein-Elbe Kanal). A review of the conditions which have led to the present demand for the extension of internal water-ways in Germany, with map and profile of the proposed canal between the Rhine and the Elbe. Two articles, 7500 w. Glaser's Annalen—July 1, 15, 1899. No. 28740 each D.

Tail Race of the Chicago Drainage Canal. Gives the original plan for the tail race, and also the present plan, explaining why the change was made. Ill. 1100 w. Eng News—July 6, 1899. No. 28454.

Canal Lift.

Canal Lift Without Gates or Locks (Schiffshebewerk ohne Haltungsthore und Schleusen). A very complete account of the Tentschert-Czischek system, in which the canal boat is floated into a cylindrical tank and rolled up an inclined plane by rope tackle. 4000 w. Zeitschr d Oesterr Ing u Arch Ver—July 7, 1899. No. 28730 B.

Coast Protection.

Foreshore Protection, with Special Reference to the Case System of Groyning. R. G. Allanson-Winn. Read before the Soc. of Engs. Describes certain methods which have recently found favor in shore protection, giving examples of works carried out under different conditions. 3400 w. Ind. & Ir—June 23, 1899. Serial. 1st part. No. 28436 A.

Computations.

A New Method of Computing Hydraulic Problems (Ueber ein Neues Rechnungsverfahren bei Aufgaben der Hydraulik). J. B. Goebel. A mathematical discussion, deriving algebraic formulas and showing their application to the flow of water through pipes. Serial. Part I. 2500 w. Gesundheits-Ingenieur—June 15, 1899. No. 28731 B.

Dam.

Geology of the Wachusett Dam and Wachusett Aqueduct Tunnel of the Metropolitan Water Works in the Vicinity of Clinton, Mass. W. O. Crosby. The present paper considers the hard rocks of this district, their distribution, characters, and general relations, with the structural details of the site of the dam. Ill. 11000 w. Tech Quar—June, 1899. No. 28520 E.

The New Masonry Dam at Holyoke. Illustrated description of a dam across the Connecticut River which has an unusual profile on the downstream face, and is being laid with special precautions to secure good workmanship. 1800 w. Eng Rec—July 22, 1899. No. 28682.

Docks.

Water Front Engineering in American Cities. Report of an investigation made by H. C. Holmes for the California State Harbor Commission. Part first gives the organization of the water front commission of Boston, New York and Philadelphia, and describes the construction of wharves in New York. 3900 w. Eng Rec—July 8, 1899. Serial. 1st part. No. 28516.

Dredging.

Alexander McDougall's Dredging System. Illustrates and describes a dredging machine for use in placer mining. 2100 w. Mod Mach—July, 1899. No. 28492.

Bucket Dredging Machine. Description with illustrations of a sea-going bucket dredger constructed for the Russian Government. 500 w. Engng—June 23, 1899. No. 28439 A.

The Largest Dipper Dredge Ever Built. Illustrates and describes a large dipper dredge recently built for use on the Great Lakes. 1500 w. Eng News—July 13, 1899. No. 28574.

The New Bates Hydraulic Dredger for the Volga. Illustrated description of a centrifugal dredge propelled by electricity and provided with cutters and a pontoon line containing many new features. 2000 w. Eng Rec—July 22, 1899. No. 28685.

Dry Dock.

The Failure of a Timber Dry-Dock. Describes the failure of Dock 2 of the Brooklyn navy yard, after nine years of service. 800 w. Eng Rec—July 29, 1899. No. 28840.

The New Dry-Dock for the U. S. Navy at Boston, Mass. Plans and description of a dock to be built of concrete, with rubble stone fillers, and lined with cut stone masonry. 1800 w. Eng News—July 20, 1899. No. 28678.

Flow.

Logarithmic Diagram for Flow of Water in Clean Cast-Iron Pipes Under Pressure. Gives a diagram devised by A. Van Muyden and reconstructed by George T. Prince with American measurements, with directions regarding its use. 900 w. Eng News—July 6, 1899. No. 28452.

Graving-Docks.

Graving-Dock Blocks and Appliances. Arthur John Maginnis. Read before the Engng. Conference of the Inst. of Civ. Engs., England. Considers keel blocks, side shores, and lifting appliances. 1600 w. Engs' Gaz—July, 1899. No. 28588 A.

New Graving Dock at Troon. Describes a recently opened dock which has been under construction for two years. Ill. 1800 w. Engr, Lond—July 14, 1899. No. 28697 A.

Harbor Improvements.

Harbor Improvements at Victoria. Extracts from the *Victoria Colonist* giving an outline of the scheme. The estimated outlay is about $5,290,000. 1000 w. U. S. Cons Repts, No. 476—July 14, 1899. No. 28590 D.

Italy.

The Utilization of the Water Powers of Italy. Enrico Bignami. A review of the possibilities which the innumerable water powers of Italy offer for the industrial salvation of the country. 4500 w. Engineering Magazine—August, 1899. No. 28783 B.

New Britain, Conn.

Roaring Brook Utilized at New Britain. An account of the work necessary to avail itself of this supply, which is drawn from a watershed of about 1,600 acres. Ill. 1000 w. Fire & Water—July 8, 1899. Serial. 1st part. No. 28532.

Pipe Lines.

Some Notable Australian Steel Pipe Lines. Information concerning the steel

pipe line with locking-bar joints, which forms a part of the water-works of Adelaide, Western Australia. Ill. 1500 w. Eng News—June 29, 1899. No. 28404.

Tide Gate.

Twin Tide Gate for the Swanson Street Canal Outlet, Philadelphia, Pa. Harrison Souder. Illustrates and describes the construction. 1000 w. Eng News—July 20, 1899. No. 28674.

Turbid Waters.

On Rapid Methods for the Estimation of the Weight of Suspended Matters in Turbid Waters. Charles L. Palmerlee and Joseph W. Ellms. A discussion in detail of the difficulties of accurate and rapid determination, noting the factors which influence the processes, and discussing methods. 7000 w. Tech Quar—June, 1899. No. 28522 E.

Water Supply.

A Tale of Two Cities: Water Supply in London and Philadelphia. Milo Roy Maltbie. Cites London as an example of private monopolies serving so poorly as to endanger the health of the people; and Philadelphia as showing official mismanagement and depreciation for the purpose of forcing the city to surrender to a corporation. 7500 w. Munic Af—June, 1899. No. 28447 C.

The New Water Supply System of Rockford, Ill. Gives an outline of the various attempts made to supply this city with an abundance of pure water, and gives an illustrated description of the interesting plant for supplying artesian water. 2500 w. Eng News—July 13, 1899. No. 28573.

Water Waste.

Preventing Water Waste in Newark, N. J. Describes an inspection to determine all the features of plumbing in houses in this city where waste is believed to occur. 1000 w. Eng Rec—July 15, 1899. No. 28596.

Water Consumption and Waste in Great Britain. A summary of the views of a number of managers of large British works, given at the convention of the Inst. of Civ. Engs. 3000 w. Eng Rec—July 15, 1899. No. 28597.

Water Works.

"All Persons Who Deal With Public Officials Act at Their Peril." Review of an important decision by the Georgia Supreme Court annulling a contract between a city and a water company because it ran for a longer term than one year, and because certain preliminaries were irregular. 1500 w. Eng Rec—July 15, 1899. No. 28592.

Notes on the Albany Water Works. Gives hints concerning hydrant maintenance and the prevention of water waste. 1100 w. Eng Rec—July 1, 1899. No. 28443.

The New Water Works of Dresden (Das Neue Dresdener Wasserwerk). A description, by Chief Engineer Vacherot, of the new system of wells and pumping engines by which the city of Dresden is supplied with water. 3000 w. 1 plate. Zeitschr d Ver Deutscher Ing—July 1, 1899. No. 28720 D.

The Water Supply of Scutari and Kadiköi (Die Wasserversorgung von Skutari und Kadiköi). Adolf Friedrich. A general description of the new water supply for 100,000 inhabitants of the suburbs of Constantinople, by impounding small streams in the adjacent valleys. 2500 w. 1 plate. Oesterr Monatschr f d Oeffent Baudienst—July, 1899. No. 28734 D.

MATERIALS.

Buckling.

The Elementary Derivation of the Formula for Buckling (Die Elementare Ableitung der Knickformel). W. Schüle. A discussion of the formula for the resistance of columns to buckling, showing how the formula may be derived without the use of the calculus. 1000 w. Zeitschr d Ver Deutscher Ing—July 1, 1899. No. 28722 D.

Cement.

Chemical Tests of Cement. John F. Wixford and S. Bent Russell. Gives the method of testing used in the chemical laboratory of the St. Louis Water Dept. 2000 w. Jour Assn of Engng Socs—June, 1899. No. 28842 C.

Plant of the Maryland Cement Company, Sparrows Point, Maryland. Frederick H. Lewis. Illustrated description of a plant making hydraulic cement from blast-furnace slag. 1000 w. Eng Rec—July 15, 1899. No. 28595.

Cement Oven.

The Economical Value of the Rotary Cement Oven (Ueber den Oekonomischen Wert der Rotierenden Cement Brennofen). L. Tetmaier. A description of various types of rotary ovens, with discussions of the economy based upon various prices for labor and fuel. 2500 w. Schweizerische Bauzeitung—June 24, 1899. No. 28745 B.

Glass.

Experiments on the Strength of Glass (Recherches sur la Résistance Mécanique du Verre). A report of the tests of the resistance of glass to bending and tension, giving a very full report of the methods and results obtained by M. Grenet upon glass of the Saint-Gobain Works. 4000 w. Bull de la Soc d'Encour—June, 1899. No. 28711 G.

Iron Protection.

Paints for Iron. Gives results of ex-

periments made to determine the best paints and pigments for ironwork, and the most effective in preventing the corrosion under conditions of great severity, showing the superiority of paints containing red lead or orange lead. 1200 w. Engr, Lond—July 14, 1899. No. 28696 A.

Pipe Test.

Second Test of a 14-in. Riveted Steel Main at New Westminster, B. C. A. McL. Hawks. Description of test and report of results. 800 w. Eng News—July 6, 1899. No. 28453.

Testing Laboratory.

The Function of a Railroad Testing Laboratory. Samuel Stockton Voorhees. Brief summary showing its importance in selecting material that will give the greatest efficiency at the lowest cost. 1500 w. Jour Assn of Engng Socs—June, 1899. No. 28843 C.

Timber.

The Injection of Structural Timber With Antiseptics (Injection des Bois de Construction par les Antiseptiques). M. Karitschkoff. An account of the results of experiments made in Russia with the alkaline wastes from the petroleum refineries, for the preservation of railway sleepers and structural timber. 3000 w. Bull de la Soc d'Encour—June, 1899. No. 28712 G.

See Architectural Engineering, Miscellany.

MEASUREMENT.

Surveying Parties.

The Equipment of Camps and Expeditions. Charles H. Snow. Presented at New York meeting of the Am. Inst. of Min. Engs. Useful hints relating to transportation, food, packing, shelter, clothing, etc. 9000 w. Trans Am Inst of Min Engs—Feb., 1899. No. 28599 D.

MUNICIPAL.

Aqueduct.

The Washington Aqueduct, 1853-1898. William R. Hutton. Illustrates and describes engineering features of the work, including graphical analyses of the 220-ft. masonry arch over Cabin John Brook, and 120-ft. arch of unsupported cast-iron water mains. 5500 w. Eng Rec—July 29, 1899. No. 28837.

Association.

The Incorporated Association of Municipal and County Engineers. A statement of the organization and work in Great Britain of a unique society of engineers for municipal works. 2200 w. Eng Rec—July 22, 1899. No. 28681.

Bacteria.

The Practical Value of Bacteriological Examinations of Water. A. M. Bleile. A criticism of bacteriological methods and a discussion of their value. 1500 w. Munic Engng—July, 1899. No. 28483 C.

Cleaning Pipe.

Cleaning Cast-Iron Water Pipe with Scrapers at St. John, N. B., and Boston, Mass. Condensed accounts of successful work in the places named. 1400 w. Eng News—July 20, 1899. No. 28679.

Disinfecting Station.

The Disinfecting Station at Genoa. James H. Fuertes. Illustrates a municipal station built to guard against contagious diseases. 1300 w. Eng Rec—July 22, 1899. No. 28684.

Drainage.

I. Ventilation of Sewers and Drains. R Read. II. House Drainage. W. H. Savage. Two papers contributed to the Cardiff meeting of the Assn. of Munic. & Co. Engs., with discussion. 6300 w. Builder—July 8, 1899. No. 28622 A.

Dwellings.

The Hygiene of Dwelling Houses (Zur Hygiene des Wohnhauses). O. Richter. A general discussion of the structural features of dwelling houses, affecting their sanitary condition; including ventilation, drainage, etc., etc. 5000 w. Oesterr f d Oeffent Baudienst—July, 1899. No. 28-736 D.

Filtration.

Test of a Mechanical Filter, East Providence, R. I. Gives the results of a run of several months under every day conditions of a filter of 500,000 gals. capacity. 1200 w. Eng Rec—July 1, 1899. No. 28-442.

Test of Mechanical Filter at East Providence, R. I. Edmund B. Weston. Gives results that were obtained during a test of 110 days of a filter for the East Providence Water Co. 1000 w. Eng News—July 13, 1899. No. 28579.

The Biology of Sand Filtration. Ad. Kemna. Abstract of a paper read before the Engineering Conference of the Inst. of Civ. Engs., England, with discussion. Shows the progress and complications in sand filtration. 3800 w. Jour Gas Lgt—June 20, 1899. No. 28400 A.

Fire Protection.

Fire Protection for the District Below Chambers Street, New York City. Francis B. Stevens. Presents a plan modified to meet the changed conditions in this business portion of the city. 4500 w. Stevens Ind—July, 1899. No. 28827 D.

Garbage Fuel.

See Electrical Engineering, Generating Stations.

Paving.

Brick Paving in the Middle West. H.

Foster Bain. Discusses the suitability of the various paving materials for small towns in the locality named, especially noting the advantages from the introduction and wide use of brick paving. Ill. 2800 w. Am Rev of Revs—July, 1899. No. 28418 C.

Experience With Wood Pavements at Ipswich, England. Describes the foundations, character of blocks and wearing properties. 900 w. Eng Rec—July 1, 1899. No. 28444.

Redwood Block Paving with Asphalt Carpeting, at Oakland, Cal. From the report of M. K. Miller, Supt. of Streets. Describes the work of paving with redwood blocks with a thin asphalt carpet, giving particulars regarding the dipping and laying of the blocks. 1200 w. Eng News—July 20, 1899. No. 28680.

Refuse.

Experience in the Municipal Utilization of House Refuse (Erfahrungen in der Stadtischen Hausmüllverwerthung). Theodor Koller. Discussing the various methods of destroying refuse to the best advantage, with especial reference to the practice in the city of Munich, Bavaria. 2500 w. Glaser's Annalen—June 15, 1899. No. 28739 D.

The New Refuse Destructors in Berlin (Der Neue Müllschmelzofen in Berlin). W. Häntzschel. A description of the new Wegener refuse destructors now in use in Berlin. The furnaces are fed with powdered coal, and very successful results are reported. 2000 w. Gesundheits-Ingenieur—June 15, 1899. No. 28732 B.

Sewage Disposal.

A Federal Decision on Sewage Disposal Nuisances. Reviews the case of a resident of one state against a city in another, and gives the court's summary of the principles of law governing nuisances to private parties from public sewerage and drainage systems. 1700 w. Eng Rec—July 29, 1899. No. 28836.

A Sewage Distributing Tank and Automatic Dosing Apparatus for Marion, Ia. F. A. Barbour. Illustrates and describes the apparatus and gives an outline of the proposed plan of treatment. 2000 w. Eng News—July 13, 1899. No. 28578.

Bacterial Purification of Sewage. Samuel Rideal. This first of a series of lectures reviews the use of cesspools, the effects of dilution, chemical precipitation, etc. 5300 w. Jour Soc of Arts—July 7, 1899. No. 28642 A.

Sewage Disposal at Brockton, Mass. Describes important practical studies on the effect of sedimentation of sewage before filtration. 2000 w. Eng Rec—July 8, 1899. No. 28514.

Sewerage.

The New Orleans Sewerage Ordinance. Describes the features of the ordinance under which the city proposes to spend many millions for drainage, sewerage and water-works. 1000 w. Eng Rec—July 15, 1899. No. 28594.

Sewers.

Sewers Laid Under Aqueducts at Newton, Mass. Henry D. Woods. Brief illustrated description of the work and statement of cost. 1100 w. Jour Assn of Engng Socs—May, 1899. No. 28401 C.

Street Improvement.

The Strand Improvement. Illustration of the proposed new route from Holborn to the Strand, with official description. 600 w. Engr, Lond—July 7, 1899. No. 28639 A.

MISCELLANY.

Address

Science and Engineering. W. H. Preece. Opening address of the president to the Engineering Conference, Institution of Civil Engineers, England. 2400 w. Jour Soc of Arts—June 23, 1899. No. 28423 A.

Early Engineering.

Early Engineering Work in the United States. Desmond Fitz Gerald. Address delivered at the annual convention of the Am. Soc. of Civ. Engs., at Cape May, N. J. Historical review of the earliest works and the men who designed and built them. 7500 w. Eng News—June 29, 1899. No. 28405.

Engineering.

The Pioneers of the Engineering Profession. Editorial giving an explanation of the slow progress of engineering in obtaining recognition. 1300 w. Eng Rec—July 1, 1899. No. 28440.

ELECTRICAL ENGINEERING

COMMUNICATION.

Africa.

The African Trans-Continental Telegraph Company. Details of the construction and working of the line to Nyassaland. Ill. 1700 w. Elec, Lond—July 7, 1899. No. 28616 A.

Duplex.

Duplex Telephony. Abstract of an article in the *Elektrotechnische Zeitschrift*, by Post-Inspector Schwensky. Reviews the progress of duplex working, illustrating various applications and giving a list of places where it is employed. 3000

w. Elect'n, Lond—July 14, 1899. No. 28808 A.

Rapid Telegraph.

High Speed Telegraph of Pollak and Virág (Schnelltelegraph von Pollak und Virág). A description of the system, and reproductions of messages sent at the rate of 100,000 words per hour. 3000 w. Elektrotech Zeitschr—July 6, 1899. No. 28768 B.

Pollak-Virág Machine Telegraph System. An illustrated description of a new invention remarkable for its extraordinary speed performance. 1400 w. Elec Wld & Elec Engr—July 15, 1899. No. 28572.

Space Telegraphy.

The Apparatus for Wireless Telegraphy. Jerome J. Green. Ilustrates and describes the parts required for complete sending and receiving stations. 2300 w. Am Elect'n—July, 1899. No. 28495.

Telephone Construction.

Essentials of Telephone Construction. Maxime Reber. Read before the Independent Telephone Assn., Chicago. Discusses things required if the system is to give efficient service under all conditions. 3800 w. W Elect'n—July 1, 1899. No. 28464.

Telephones.

The Municipalization of the Telephone. A. B. Mountain. Read at the convention of the Municipal Electrical Assn., Bristol, England. Reviews efforts made to improve the telephone service in England, and endeavors to prove that if controlled by local authorities the rates can be reduced and the system developed. Discussion. 3300 w. Elec Eng, Lond—June 23, 1899. No. 28427 A.

See Railway Affairs, Permanent Way and Fixtures.

DISTRIBUTION.

Alternating Currents.

Notes on Distribution of Electricity. Charles D. Taite. Read before the Municipal Elec. Assn., England. Reviews recent changes in distribution, especially in alternating-current practice. Discussion. 3500 w. Elec Eng, Lond—June 24, 1899. No. 28428 A.

Philadelphia.

The Distribution of Electricity in Philadelphia. Gives the pole and wiring regulations of a city remarkable for its immunity from trouble with electrolysis. 1700 w. Eng Rec—July 22, 1899. No. 28687.

Protection.

The Protection of Low Tension Wiring Against Dangerous High Potential Currents. W. J. Plews. Read before the Canadian Elec. Assn. Calls attention to the dangers due to a change in the system of secondary distribution, and considers apparatus to protect equipments. 900 w. Can Elec News—July, 1899. No. 28609.

The Protection of Secondary Circuits from Fire Risks. Cary T. Hutchinson. A paper presented at the Boston meeting of the Am. Inst. of Elec. Engs. A statement of the various possible consequences of a failure of insulation and the means of prevention. 3800 w. Elec, N. Y. —July 5, 1899. No. 28496.

Short-Distance.

Short Distance Electric Power Distribution. James Swinburne. A characteristic discussion of the defects of existing practice, and of the general expediency of electric driving as a substitute for other methods. 2500 w. Engineering Magazine—August, 1899. No. 28787 B.

Switchboards.

Electric Switchboards and Their Use. William Baxter, Jr. Illustrates and describes the various devices and explains their use. 2200 w. Am Mach—July 20, 1899. No. 28656.

Transformation.

Transformation from Three-Phase to Two-Phase Currents. P. G. Watmough. An illustrated explanation of the manner in which the change is effected. 700 w. Elec Wld & Elec Engr—July 22, 1899. No. 28661.

ELECTRO-CHEMISTRY.

Battery.

A New Primary Battery. J. D. Darling. Illustrates and describes the Harrison cell, the process of its manufacture, and the manner of overcoming galvanic polarization and local action. 2800 w. Jour Fr Inst—July, 1899. No. 28486 D.

Electric Energy.

On the Oxidation of Carbon at Ordinary Temperatures by Means of Atmospheric Oxygen with the Production of Electrical Energy. Willard E. Case. Presented before the Royal Society. Investigations in which ferric chloride was used as the carrier of oxygen. 4000 w. Elec Wld & Elec Engr—July 22, 1899. No. 28662.

Electrolysis.

Electrolysis at Places Apart from Electrodes. F. T. Trouton. A short account of experimental investigations showing that decomposition can take place at unsuspected places. 800 w. Elect'n, Lond —June 23, 1899. No. 28429 A.

Sterilisation.

The Industrial Sterilisation of Water

by Ozone (La Sterilisation Industrielle des Eaux Potables par l'Ozone). A discussion of the process of MM. Marmier and Abraham, reviewing the operation of the plant at Lille. 2500 w. Revue Technique—June 25, 1899. No. 28708 D.

ELECTRO-PHYSICS.

Coherers.

The Nature and Cause of the Phenomena in Coherers (Sur la Nature et la Cause du Phénomène des Cohèreurs). Thomas Tommasina. A note to the French Academy giving the results of the writer's investigations at the laboratory of the University at Geneva. 1200 w. Comptes Rendus—July 3, 1899. No. 28716 D.

Condensers.

Condensers. Harold B. Smith. Considers the various types. 1200 w. Jour Worcester Poly Inst—July, 1899. No. 28819 C.

Contact Maker.

A Simple Form of Instantaneous Contact Maker. Jonathan Haralson, Jr. Brief illustrated description of an instrument which has been in use in the electrical laboratory of the Alabama Polytechnic Inst. and has given satisfactory results. 450 w. Elec Wld & Elec Engr—July 15, 1899. No. 28571.

Electric Waves.

Reflection of Hertzian Waves at the Ends of Parallel Wires. Lee De Forest. Describes experimental investigations. 4000 w. Am Jour of Sci—July, 1899. No. 28422 D.

Velocity of Electric Waves in Air. G. V. Maclean. Briefly notes methods used by various experimenters, and describes an experiment in which a new method was employed, by which the direct determination of the period of the oscillator was found. 5400 w. Am Jour of Sci—July, 1899. No. 28420 D.

Velocity of Propagation of Electro-Magnetic Waves Through Air and Through Wires (Comparison des Vitesses de Propagation des Ondes Electro-Magnetiques dans l'Air et le Long des Fils). A communication to the French Academy by M. Gutton, describing the apparatus and method by which the tests were made, and showing the velocity to be alike in both cases. 1200 w. Comptes Rendus—June, 1899. No. 28714 D.

Interrupter.

A Modification of the Wehnelt Interrupter (Ueber eine Abänderung des Wehnelt'schen Stromunterbrechers). H. T. Simon. A claim that the improved interrupter described by Caldwell had been previously invented by the writer. 2000 w. Elektrotech Zeitschr—June 22, 1899. No. 28762 B.

An Improved Liquid Interrupter for Rhumkorf Coils. A. A. Campbell Swinton. Description with illustration. 500 w. Elect'n, Lond—June 30, 1899. No. 28544 A.

The Theory of the Wehnelt Interrupter (Beitrag zur Theorie des Wehnelt'schen Unterbrechers). Ernst Ruhmer. Notes of experiments made by the writer, confirming the theory of the generation and condensation of gas at the point of interruption. 2500 w. Elektrotech Zeitschr—June 29, 1899. No. 28765 B.

Wehnelt Interrupter Phenomena. Illustrates and describes experimental work conducted in the electrotherapeutic laboratory of the University of Michigan. 2300 w. Elec Wld & Elec Engr—July 29, 1899. No. 28832.

Magnets.

Steel for Magnets (Sur les Aciers à Aimants). A communication to the French Academy by M. Osmond, giving the results of investigations as to the influence of the chemical composition of steel upon its suitability for permanent magnets. 1000 w. Comptes Rendus—June 19, 1899. No. 28715 D.

Radiation.

Radiant Electric Forces. Alfred G. Dell. Deals briefly with some of the forces radiated from induction coils, and their discharges in vacuum tubes. 1500 w. Elec Rev, N. Y.—June 28, 1899. No. 28473.

GENERATING STATIONS.

Accounting.

Central Station Accounting from a Business Standpoint. P. H. Hart. Read before the Canadian Elec. Assn. Gives reasons why a standard system should be adopted, and describes a system which the author thinks can be readily put in operation by any company. 3800 w. Can Elec News—July, 1899. No. 28610.

Corporation Electricity Works Accounts. H. M. Stevens. Read at Plymouth meeting of the Corporate Treasurers' and Accountants' Inst. Reviews the form of acounts adopted by the British Board of Trade, discussing the arrangement, and the forms and books used in connection with the system, and related matters. 3800 w. Elec Eng, Lond—July 14, 1899. No. 28807 A.

Accumulators.

See Street and Electric Tramways.

Alternating Current.

Alternating-Current Generators and Transformers. Alton D. Adams. Illustrated detailed description of these machines and their operation. 9000 w. Engr, U. S. A.—July 1, 1899. No. 28465.

Ashton.

Ashton Corporation Electricity Works, and the Oldham, Ashton and Hyde Electric Tramway. Illustrates and describes an installation possessing features of interest. 4500 w. Elec Rev, Lond—July 14, 1899. No. 28806 A.

Condensers.

Condensers for Electric Light and Power Stations. J. F. C. Snell. Read at the Bristol convention of the Munic. Elec. Assn. Considers the advantages from the adoption of condensers, and the type to be selected, favoring surface condensers as a rule. Discussion. 6000 w. Elec Eng, Lond—June 30, 1899. No. 28545 A.

Garbage Fuel.

English Experience with Garbage as Fuel for Electric Light Stations. A. H. Campbell. Abstract of a paper presented at a recent meeting of the Munic. and Co. Engs., England. Indicates a belief in the possibilities of utilizing garbage for this purpose. 600 w. Eng News—July 13, 1899. No. 28575.

Isolated Plant.

The Lighting Plant at the Landonviller Castle near Metz (Beleuchtungsanlage des Schlosses Landonvillers bei Metz). G. Klingenberg. A description of a small isolated plant in which a water-power nearly a mile distant is utilized. 4000 w. Elektrotech Zeitschr—July 8, 1899. No. 28767 B.

Newington Vestry.

The Newington Vestry Electricity Works. Illustrated detailed description of the works. 2500 w. Elec Rev, Lond—June 23, 1899. No. 28430 A.

Paris.

The Electric Plant of the Paris Electric Cab Company (Usine Electrique de la Compagnie Générale des Voitures, à Paris). Showing the generating plant and the system adopted for charging the batteries. 2000 w. Revue Technique—June 25, 1899. No. 28707 D.

Park Row Building.

The Generating Plant, Distributing System and Transportation Facilities of the Highest Office Building in the World. Illustrated detailed description of these features of the Ivins Syndicate or Park Row Building of New York. 3300 w. Elec Wld & Elec Engr—July 1, 1899. Serial. 1st part. No. 28409.

Power Stations.

See Street and Electric Tramways.

Speed Regulation.

Elements of Design Favorable to Speed Regulation in Plants Driven by Water-Power. Allan V. Garratt. Presented at the Boston meeting of the Am. Inst. of Elec. Engs. Describes those peculiarities of design which have a special bearing on speed regulation. Ill. 3000 w. Elec Rev, N. Y.—July 26, 1899. Serial. 1st part. No. 28814.

Statistics.

Statistics of Electric Plants in Germany (Statistik der Elektricitätswerke in Deutschland). The annual tabulated statement of power and lighting plants in Germany, brought down to March, 1899, with editorial discussion. 15000 w. Elektrotech Zeitschr—July 8, 1899. No. 28766 B.

Taunton.

Taunton Electric Supply Works: Old and New. Illustrates and describes the present plant, and reviews the development since 1886. 1300 w. Elect'n, Lond—June 30, 1899. No. 28543 A.

Transformers.

Transformer Economy. F. H. Leonard, Jr. Read before the Can. Elec. Assn. On the practical use and high efficiency of the apparatus, and matters relating. 4000 w. Can Engr—July, 1899. Serial. 1st part. No. 28601.

HEATING AND WELDING.

Electric Heating.

Electric Heating. Alton D. Adams. Discusses the energy from various heating devices, the cost, where electric heating can be used with advantage, etc. 1700 w. Sci Am—July 15, 1899. No. 28562.

LIGHTING.

Arc Lamps.

The Siemens & Halske Hanging Lamp (Seillampe von Siemens & Halske A. G.). Görges and Queisser. A discussion of the comparative merits of the differential and the shunt lamp, with especial reference to the Siemens & Halske differential lamp. 6000 w. Elektrotech Zeitschr—June 22, 1899. No. 28763 B.

Charge System.

Wright's, or the Maximum Charge System for Electric Light. An explanation of this system, which is becoming widely adopted in England. 1800 w. Engr, Lond—June 30, 1899. No. 28557 A.

Hartford, Conn.

The Series Alternating Current Arc System in Hartford. Describes the extensions made and contemplated. Ill. 1500 w. Am Elect'n—July, 1899. No. 28494.

Illumination.

Distribution of Lights for Illumination. J. H. Kinealy. Part first discusses the things to be considered in designing a

lighting system, the standard of intensity, etc., giving opinions of writers on this subject. 2500 w. Heat & Ven—July, 1899. Serial. 1st part. No. 28812.

Regulation.

Arc Machine Regulation. H. Franklin Watts. Remarks on the systems of regulation employed, criticizing some of the regulators, and suggesting a remedy for their shortcomings. 1700 w. Elec Wld & Elec Engr—July 29, 1899. No. 28830.

Ship Lighting.

Suggestions for the Selection of Electric Lighting Sets for Ship Use. Alton D. Adams. Emphasizes durability and simplicity in design in selection of the plant, and gives valuable suggestions. 2800 w. Marine Engng—July, 1899. No. 28539 C.

MEASUREMENT.

Currents.

A Portable Apparatus for Photographing Curves of Two Variable Currents Simultaneously. Describes and illustrates the apparatus and its uses. 1600 w. Elec Wld & Elec Engr—July 22, 1899. No. 28663.

Frequency.

A Simple Method of Measuring the Duration of Period of an Alternating Current (Ueber eine Einfache Methode zur Messung der Periodendauer von Wechselströmen). Walter König. The measurement is made by the use of an electroscopic powder of sulphur and red lead, which, when shaken on a plate over which a wire carrying the current has been drawn, shows the positive and negative points. 1200 w. Elektrotech Zeitschr—June 15, 1899. No. 28758 B.

On a Method of Measuring the Frequency of Alternating Currents. Harrison W. Smith. Briefly describes a method recently employed for measuring variations in the frequency of currents of about 120 alternations per second. 1200 w. Tech Quar—June, 1899. No. 28524 E.

High Tension.

A New Laboratory Apparatus for the Production of High Tension Continuous Currents (Ueber einen Neuen Laboratoriumsapparat zur Erzeugung Hoher Gleichstromspannungen). L. Strasser. A number of secondary elements are used in connection with a rotary collector and commutator. 1200 w. Elektrotech Zeitschr—July 13, 1899. No. 28771 B.

Instruments.

Electric Measuring Instruments (Instruments de Mesures Electriques). Report of committee upon the instruments of MM. Chauvin and Arnoux, including volt meters, ampere meters, recording galvanometers, resistance coils, etc., etc., with many illustrations. 7500 w. Bull de la Soc d'Encour—June, 1899. No. 28710 G.

Meters.

Meters and Meter Rates. A. A. Dion. A consideration of the importance of meters in connection with electric-light plants, discussing the desirable characteristics, testing, methods of charging, etc. 6500 w. Can Engr—July, 1899. No. 28600.

Methods.

Electrical Measurements. Henry A. Rowland and Thomas Dobbin Penniman. An account of experiments performed and methods used, with a method for the direct measurement of the effect of electric absorption in terms of resistance. 5800 w. Am Jour of Sci—July, 1899. No. 28421 D.

Permeameter.

Design, Construction and Test of a Special Type of Permeameter. R. R. Knowles and F. W. Putnam. Sketch of the instrument, with illustration. 1400 w. Jour Worcester Poly Inst—July, 1899. No. 28820 C.

Polyphase Testing.

Polyphase Electric Testing. Harris J. Ryan. Read at Boston meeting of the Am. Inst. of Elec. Engs. Treats of a method that employs a polyphase source for making instantaneous measurements of alternating currents or pressures without the use of a contact-maker. 2000 w. Elec Rev, N. Y.—July 5, 1899. No. 28530.

Standardization.

Electrical Standardization. Report adopted at the Boston meeting of the Am. Inst. of Elec. Engs. Part first gives the classification of apparatus. 1100 w. Elec Wld & Elec Engr—June 8, 1899. Serial. 1st part. No. 28525.

Synchronism.

Synchronism Indicator for Use with Parallel Alternating Currents (Einige Anordnungen von Synchronismusanzeigern zum Parallelschalten zweier Wechselstromquellen). Hermann Müller. A combination of a fixed and movable rotary field, with a pointer, the displacement of which indicates any departure from synchronism. 1800 w. Elektrotech Zeitschr—June 15, 1899. No. 28759 B.

Transformer Testing.

A Differential Method for Testing a Single Transformer. S. E. Johannesen. Describes a method devised by the writer, by which a single transformer may be tested under actual working loss condi-

tions with an energy consumption equivalent to the transformer losses alone. 1700 w. Elec Wld & Elec Engr—July 29, 1899. No. 28829.

Units.

On a Possible and Rational Simplification of Electric Units. A Blondel. On the desirability of promoting the practical use of the C. G. S. system, with suggestions. 2000 w. Elec Wld & Elec Engr—July 29, 1899. No. 28831.

POWER APPLICATIONS.

Electricity.

See Mining and Metallurgy, Mining.

Induction Motor.

Design for a One Horse-Power Two-Phase Induction Motor. Cecil P. Poole. Illustrated instructions for building such a motor. 2000 w. Power—July, 1899. No. 28413.

Machine Driving.

Independent Electric Driving (Elektrischen Einzelantrieb). O. Lasche. A discussion upon the relative advantages of continuous and polyphase currents for electric driving. 4500 w. Zeitschr d Ver Deutscher Ing—July 1. 1899. No. 28723 D.

Single Phase.

The Single Phase Induction Motor (Der Einphasen-Induktionsmotor). C. P. Steinmetz. With a mathematical analysis of the action, and curves to aid in design and tables of constants. Two articles, 4500 w. Elektrotech Zeitschr—June 22, 29, 1899. No. 28761 each B.

TRANSMISSION.

Power Transmission.

Power Transmission by Direct and Alternating Currents. A criticism of Mr. Swinburne's results as given in the paper presented at the Engineering Conference. The cases considered in the paper are worked out and the results given. 1100 w. Elec Rev, Lond—July 7, 1899. No. 28618 A.

Switzerland.

Legislation Concerning the Installation of High and Low Tension Electric Transmissions (Bundesgesetz betreffend die Elektrischen Schwach und Starkstromanlangen). With the full text of the recent Swiss law, based upon the report of an expert commission. 4000 w. Schweizerische Bauzeitung—June 30, 1899. No. 28746 B.

MISCELLANY.

Clocks.

The Electric Master Clock System in the City of Karlsruhe, Baden (Die Elektrische Centraluhrenanlage der Haupt und Residenzstadt Karlsruhe, i. B.). Emil Giehne. With illustrations of the master clock, and of the escapement used on the auxiliary dials. Serial, Part I. 1800 w. Elektrotech Zeitschr—July 13, 1899. No. 28772 B.

Cost.

Computations of the Cost of Alternating Currents (Berechnung des Strompreises bei Wechselströmen). G. Benischke. A discussion of a convenient method of computing current costs by the use of efficiency factors. 2000 w. Elektrotech Zeitschr—June 29, 1899. No. 28764 B.

Paris Exposition.

The Electrical Installation for the 1900 Paris Exposition. Georges Dary. Information concerning the buildings in which will be installed the electrical power appliances, and details of the electrical features. Ill. 3000 w. Elec Wld & Elec Engr—July 15, 1899. No. 28570.

GAS ENGINEERING

Acetylene.

The Calcium Carbide and Acetylene Gas Industries. John B. C. Kershaw. Cautionary remarks, giving information concerning the production and utilization. 2000 w. Elec Rev, Lond—July 7, 1899. No. 28620 A.

The Present Status of the Acetylene Industry (Ueber den Jetzigen Stand der Acetylen-Technik). A general review of the various methods of generating acetylene now in use, together with the conditions of safe and economical use. Three articles. 3500 w. Schweizerische Bauzeitung—June 10, 17, 24, 1899. No. 28743 each B.

Bench Firing.

Isolated Generators for Bench Firing. Presented at Milwaukee meeting of the Western Gas Assn. Reports of Fred. Bredel, William Steinwedell, and Irwin Butterworth, with discussion. Ill. 7500 w. Pro Age—July 15, 1899. No. 28615.

Coke Oven Gas.

The Application of Coke-Oven Gas for Illuminating Purposes (Verwendung von Koksofengas zu Beleuchtungszwecken). With analyses of gases produced by various ovens, showing that a valuable excess of gas remains even after a portion is used for heating the ovens. 2000 w.

Stahl und Eisen—July 1, 1899. No. 28750 D.

The Utilization of Coke-Oven Gas for Lighting. From *Stahl und Eisen.* Considers the causes of contamination in coke-oven gases, and the consequent inferior quality, and other subjects related which affect the economy. 1700 w. Col Guard—July 14, 1899. No. 28803 A.

Cyanides.

Cyanides in the Gas and Waste Products at Columbus O. E. E. Eysenbach. Read before the Western Gas Assn. Gives the results of quantitative determinations, and concludes that higher percentages are necessary before the cyanides can be extracted economically. Discussion. 1500 w. Am Gas Lgt Jour—July 3, 1899. No. 28472.

Distribution.

Distributing Gas Under Higher Pressure. F. H. Shelton. Read before the Western Gas Assn., at Milwaukee. Considers whether it would not be of advantage to distribute gas at higher pressures than is common practice. Followed by general discussion. 7000 w. Am Gas Lgt Jour—July 17, 1899. No. 28611.

Foundations.

A Foundation That Failed and the Lesson It Taught. B. E. Chollar. Read before the Western Gas Assn. Explains the cause of unequal settlement which damaged a gasholder tank in St. Louis. Discussion. 2200 w. Am Gas Lgt Jour—July 3, 1899. No. 28471.

Mains.

Vitrified Clay Pipe Instead of Iron for Gas Mains. Irvin Butterworth. Read before the Western Gas Assn., at Milwaukee. Considers the properties that indicate the suitability of vitrified clay pipes for this use. Discussion. 3000 w. Am Gas Lgt Jour—July 17, 1899. No. 28612.

MARINE AND NAVAL ENGINEERING

Battleship.

Launch of the Battle-Ship "Kaiser Wilhelm der Grosse" (Stapellauf S. M. Linienschiff "Kaiser Wilhelm der Grosse"). With reproductions of photographs of the vessel on the ways and in the water. A brief account of the launch and a description of the ship are given. 1000 w. Stahl und Eisen—July 1, 1899. No. 28748 D.

Our Latest Battleship, the "Kearsarge." Brief illustrated account of the new American battleship and its armament. 1000 w. Sci Am—July 15, 1899. No. 28565.

The Canopus. Illustration with notes on some details not previously noticed. 600 w. Engr, Lond—July 14, 1899. No. 28698 A.

The Imperial Japanese Battleship "Hatsuse." Illustrated detailed description of this example of latest development in naval architecture. 1500 w. Engr, Lond—June 30, 1899. No. 28559 A.

The Launch of the Kaiser Wilhelm der Grosse. This vessel is one of a group of three turret ships building for Germany. Gives dimensions, illustrations and particulars. 600 w. Engr, Lond—July 7, 1899. No. 28637 A.

The United States Battleship "Maine." Illustration and description of this typical vessel of the three battleships recently ordered by the U. S. Congress. 1500 w. Engr, Lond—July 7, 1899. No. 28634 A.

Boilers.

Boilers for Torpedo Boats (Les Chaudières des Torpilleurs). A comparison between locomotive and water-tube boilers, with especial reference to the circular of the French Minister of Marine, regarding the requirements for the French service. 2000 w. Le Yacht—July 15, 1899. No. 28757 D.

Cold Storage.

U. S. Cold Storage Ship "Glacier." Gives a description of the vessel and its machinery, which takes cargo of frozen meat to Manila. 600 w. Ice & Refrig—July, 1899. No. 28487 C.

Cruisers.

Characteristics of the New Protected Cruisers of the Denver Class. Brief notes on the chief characteristics, dimensions and features of six new cruisers for the United States Navy. Ill. 900 w. Marine Engng—July, 1899. No. 28536 C.

H. M. SS. "Hermes" and "Highflyer." Engraving, with illustrations of the machinery of these second-class cruisers lately completed for the British navy, with description. 2000 w. Engng—July 7, 1899. No. 28624 A.

The Reconstructed Cruiser "Chicago." An illustrated account of the changes and improvements. 2500 w. Sci Am—July 15, 1899. No. 28564.

Destroyer.

Engines and Boiler; Japanese Torpedo-Boat Destroyer "Akebono." Illustrated description. 1000 w. Engng—June 30, 1899. No. 28550 A.

Germany.

The Development of German Shipbuilding. Rudolph Haack. The first of an important series of papers dealing with the enormous growth of shipbuilding in Germany since the consolidation of the empire in 1871. 3500 w. Engineering Magazine—August, 1899. No. 28780 B.

Losses.

From Furnace to Propeller—A History of the Energy Losses Which Occur on the Way. Edmund Leavenworth. Traces the losses, showing that only about 7.26 per cent. is utilized, and urging engineers to work for the decrease of losses. 3300 w. Marine Engng—July, 1899. No. 28537 C.

Merchant Marine.

The Rise and Fall of the American Merchant Marine. Joseph R. Oldham. Refers particularly to the foreign trade, considering some of the features that contributed to its decay, and claiming that the time is now ripe for its revival. Discussion. 6000 w. Jour Assn of Engng Socs—May, 1899. No. 28403 C.

River Steamer.

Record-Breaking Stern-Wheel Steamer "Hassalo" for Columbia River. Illustrates and describes a new river steamer built for the Oregon Railroad & Navigation Co. 1100 w. Marine Engng—July, 1899. No. 28538 C.

Salvage.

The S. S. Milwaukee. An account of an interesting and noteworthy feat of marine salvage and repair, with numerous illustrations. 600 w. Engr, Lond—June 30, 1899. No. 28558 A.

Shipbuilding.

Naval Architecture. Vernon D. Cox. From *The Independent.* Notes on the art and practice of shipbuilding. 1700 w. Sci Am Sup—July 8, 1899. No. 28450.

The Stettiner Maschinenbau Actien-Gesellschaft "Vulcan." Interesting information concerning the Vulcan Works at Bredow, near Stettin, Germany, the great progress, especially during the last ten years, giving diagrammatic profiles of work done. The success of the twin-screw Atlantic liner "Kaiser Wilhelm der Grosse," and comparison with other vessels. 3800 w. Engng—July 7, 1899. Serial. 1st part. No. 28623 A.

Ship Lighting.

See Electrical Engineering, Illumination.

Shipyard.

Model American Shipyard. Illustrates and describes the plant of the Harlan & Hollingsworth Co., of Wilmington, Del., its equipment and operation. 3300 w. Marine Rev—July 13, 1899. No. 28604.

Steamboats.

Some Early Thames Steamboats. An account of these boats and their work, dating back to 1815. 2400 w. Engr, Lond—July 7, 1899. No. 28638 A.

Testing Tank.

The Navy's New Experimental Tank. Description of the new basin at the Washington navy yard, which will be used for the purpose of experimenting with warship models. 3000 w. Naut Gaz—July 13, 1899. No. 28603.

The New Government Testing Tank for Ship Models at the Washington Navy Yard. D. W. Taylor. An interesting illustrated account of basin at the Washington navy yard, the method of building the models, and conducting the experiments, etc. 3000 w. Eng News—July 6, 1899. No. 28451.

The United States Experimental Model Basin. An illustrated description of the experimental basin at the Washington navy yard, recently completed. 3500 w. Sci Am—July 8, 1899. No. 28448.

The U. S. Navy Experimental Model Basin. An illustrated description of the testing tank at Washington, D. C., with a description also of the apparatus and method of experimenting. 2800 w. Am Mach—July 6, 1899. No. 28461.

Yacht.

Cup Defender Columbia. Illustration with description of this recently completed racing craft, which is representative of the latest developments in yacht construction. 1500 w. Marine Rev—June 29, 1899. No. 28468.

The Columbia. Particulars and features of the new cup defender, with brief history of the cup races. Ill. 1700 w. Naut Gaz—July 6, 1899. No. 28531.

MECHANICAL ENGINEERING

AUTOMOBILISM.

Association.

A National Automobile Association. An editorial calling attention to features of the situation which make the organization of such a body desirable. 1000 w. Elec Rev, N. Y.—July 19, 1899. No. 28649.

A National Automobile Association. Editorial suggesting the organization of such an association. 400 w. Elec Rev, N. Y.—July 12, 1899. No. 28648.

Competition.

The Second Competition of Automobile Cabs (Deuxième Concours des Fiacres Automobiles). With descriptions of the competing vehicles, and a summary of the results of the trials. 4000 w. Génie Civil—June 24, 1899. No. 28703 D.

Electric Vehicles.

Electric Automobiles. Elmer A. Sperry. Read at Boston meeting of the Am. Inst. of Elec. Engs. Discusses types of batteries, tires, problems to be solved by designers, etc. 3900 w. Elec, N. Y.—July 19, 1899. No. 28650.

Riker's Electric Wagons. Hugh Dolnar. Working drawings showing the principal mechanical inventions in motor wagons made by this establishment, with explanation of methods. 2200 w. Am Mach—July 13, 1899. No. 28584.

Fire Wagon.

An Electric Fire Wagon. Illustrates and describes a vehicle with electrical equipment, designed for the Paris Fire Brigade, and reports highly encouraging experimental trials. 1200 w. Engr, Lond—July 7, 1899. No. 28641 A.

Motor Cycles.

The Bicycle as a Motor Vehicle (Das Fahrrad als Droschke). K. Hallbauer. With numerous illustrations showing motor vehicles designed on the lines of the bicycle and tricycle, and adapted for delivery vehicles and general use. 1200 w. Glaser's Annalen—June 15, 1899. No. 28738 D.

Motor Vehicles.

Early Motor Vehicles and Modern Practice. Illustrated notes of early steam carriages. 1700 w. Automotor Jour—June, 1899. No. 28408 A.

Operating Cost.

Operating Cost of Horse and Electric Delivery Wagons in New York City. Abstract of a paper read at the meeting of the Am. Inst. of Elec. Engs. Comparison of cost of operating in favor of the electric vehicles, with statement of advantages. 4500 w. Elec Wld & Elec Engr—July 8, 1899. No. 28526.

Paris.

Motor Cars in Paris. Comments on the vehicles at the late exhibition, the lack of novelty, but evidences of improvement, the power used, etc. 2200 w. Engr, Lond—July 14, 1899. No. 28800 A.

Steam Motor-Cars.

Some American Steam-Driven Motor-Vehicles. Horace L. Arnold. Illustrates and describes four vehicles made in or near Boston, which collectively exhibit all the features of an ideal automobile. 2000 w. Ind & Ir—June 30, 1899. Serial. 1st part. No. 28547 A.

HYDRAULICS.

Hydraulic Plant.

The East Jersey Water Company's Hydraulic Plant at Little Falls, N. J. Illustrated description of a station designed to have an ultimate capacity of 120,000,000 gals. daily, and fitted with turbines and power pumps designed by Prof. A. Riedler. 2000 w. Eng Rec—July 8, 1899. No. 28515.

Niagara.

The Utilization of Niagara Falls (Utilisation des Chutes du Niagara). Georges Henry. A description of the extension of the Niagara power plant, with numerous illustrations and a plate of details of the turbines. 3500 w. 1 plate. Génie Civil—June 17, 1899. No. 28700 D.

Pumping.

Pumping Engines Driven by Water Power. Charles A. Hague. The article is confined to pumping engines wherein the pinion shaft is driven by gears from a turbine shaft. 2000 w. Eng News—July 6, 1899. No. 28455.

Triple Expansion Pumping Engine for the Cleveland, O., Water Works. Illustrates and describes the new 20,000,000 gallon engine recently erected. It is of the vertical triple-expansion type. 1200 w. Power—July, 1899. No. 28412.

See Mining and Metallurgy, Mining.

Speed Regulation.

See Electrical Engineering, Generating Stations.

MACHINE WORKS AND FOUNDRIES.

Band-Sawing.

Band-Sawing a Bevel Pinion. W. H. Freeman. Illustrated description of the method used. 1200 w. Am Mach—July 20, 1899. No. 28657.

Bolt Heads.

Report on Comparative Test of Bolt Heads. W. Kendrick Hatt. Explains the purpose of the tests, and their results, with discussion. Presented at the Convention of the Master Car Builders' Assn. 2700 w. R R Car Jour—July, 1899. No. 28490.

Castings.

Pig Iron for Malleable Castings. C. E. Wheeler. Deductions gathered from experience concerning heat influences, silicon, sulphur and phosphorus. 3800 w. Ir Trd Rev—July 13, 1899. No. 28568.

The Warping of Castings and the Remedy. R. D. Moore. Suggestions for the prevention of warping and for straightening. 1500 w. Am. Mach—July 13, 1899. No. 28586.

Cast-Iron Pipes.

The Manufacture and Inspection of Cast-Iron Pipes. Thomas H. Wiggin. An illustrated description of the process of pipe making and inspecting, giving tests and conclusions. 21000 w. Jour Assn of Engng Socs—May, 1899. No. 28402 C.

Dies.

Die Construction. George B. Painter. Illustrates a die for shearing and drawing a piece of sheet metal into the form of a cup with irregular edges. 700 w. Am Mach—July 20, 1899. No. 28658.

Drills.

Setting Diamond Drill Bits. Practical instructions, with illustrations, prepared by J. Parke Channing and published by the Sullivan Machinery Co. 900 w. Eng & Min Jour—July 15, 1899. No. 28605.

Forging Press.

A Great Forging Press (Grosse Schmiedepressen). An illustrated description of the 10,000 ton hydraulic forging press recently built by Breuer, Schumacher & Co. for the Dillingen Iron Works, Germany. 1000 w. 2 plates. Stahl und Eisen—July 1, 1899. No. 28749 D.

Foundry Practice.

Latter Day Foundry Progress. Translation and comment by Dr. Richard Moldenke, of Prof. A. Ledebur's review of the development of foundry practice during the last half of the 19th century, as published in the *Zeitschrift des Vereins Deutscher Ingenieure*. 3000 w. Ir Trd Rev—June 29, 1899. No. 28411.

Iron Mixtures.

Governing Mixtures by Silicon. A contribution to the discussion of a paper by Bertrand S. Summers, read at the Buffalo meeting of the Am. Inst. of Min. Engrs. 4000 w. Ir Trd Rev—July 13, 1899. No. 28569.

Iron Works.

See Mining and Metallurgy, Iron and Steel.

Machine Tools.

Machine Tools to Be Installed in the New Building at New York Navy Yard. A complete list. 800 w. Am Mach—July 20, 1899. No. 28655.

Match Works.

The Works of the Diamond Match Company, Limited. Illustrated detailed description. 2500 w. Engr, Lond—July 7, 1899. Serial. 1st part. No. 28636 A.

Power Shear.

A Power Shear With a Peculiar Movement. Illustrated description. 600 w. Am Mach—July 6, 1899. No. 28459.

Precision Lathe.

Some of the Products of Professor W. A. Rogers' Precision Lathe. An illustrated description of some of the more important pieces of work done on the lathe before its destruction by fire. 2200 w. Am Mach—July 27, 1899. Serial. 1st part. No. 28816.

Premium Plan.

The Administration of the Premium Plan. F. A. Halsey. The purpose of the article is to show just how the plan is carried out in some of the shops where it it used. 1800 w. Am Mach—July 6, 1899. Serial, 1st part. No. 28460.

Repairing.

Machinery Repairing. F. A. Farnsworth. Gives suggestions for tempering, case-hardening, etc. Ill. 1000 w. Engr, U. S. A.— July 1, 1899. No. 28467.

Special Tools.

Special Tools for Setting and Holding Work. H. S. Brown. Brief description of useful tools. Ill. 1400 w. Am Mach —July 6, 1899. No. 28462.

Springs.

Some Constants for Use in Designing Elliptic Springs. F. F. Gaines. Gives constants which have proven their correctness and value. 1000 w. Am Mach—July 20, 1899. No. 28660.

Steel Bin.

A Novel Design for a Steel Bin for the Storage of Coal, Grain, Sand or Cement. A. S. Berquist. Illustrates and describes the construction of a bin erected for the American Coffee Co., of Brooklyn, N. Y. 1200 w. Eng News—July 27, 1899. No. 28834.

Tools.

Crank-Hanger Jigs and Tools. A. H. Cleaves. Illustrated descriptions. 600 w. Am Mach—July 13, 1899. No. 28585.

Machine Tools, with Special Reference to American and German Practice as Compared with English. Arthur Greenwood. Read before the Engng. Conference of the Inst. of Civ. Engs., England. Discusses the tools under four classes—planing machines, lathes, milling machines and automatic. Discussion. 3800 w. Engr, Lond—April 23, 1899. No. 28434 A.

Tubing.

The Production of Seamless Tubing. H. S. Wilson. Describes the oldest methods and traces the various changes which have led to modern practice. Ill. 4900 w. Jour Assn of Engng Socs—June, 1899. No. 28841 C.

Wire Works.

The British Insulated Wire Company's

Works at Prescot. Illustrated description of the works and the process by which the cables are manufactured. 3000 w. Elect'n, Lond—July 7, 1899. No. 28-644 A.

Works Management.

Machine Shop Management in Europe and America. H. F. L. Orcutt. The conclusion of Mr. Orcutt's notable series of papers, giving his final opinions as to the details of a standard shop design. 3000 w. Engineering Magazine—August, 1899. No. 28781 B.

MATERIALS OF CONSTRUCTION.

Expansion.

The Expansion of Metallic Alloys (Sur la Dilatation des Alliages Metalliques). H. Le Chatelier. A communication to the French Academy discussing especially the behaviour of alloys of copper and antimony, and copper and aluminum, with curves showing the relation of expansion to the percentage of copper present. 1200 w. Comptes Rendus—June 12, 1899. No. 28713 D.

Torsion Testing.

An Inexpensive Autographic Torsion Testing Apparatus. Robert A. Bruce. Illustrates and describes a design and the method of operating it. 1200 w. Am Mach—July 20, 1899. No. 28659.

POWER AND TRANSMISSION.

Air Transmission.

The Friction of Compressed Air in Pipes. J. E. Johnson, Jr. Gives diagrams for facilitating calculations, and explains the cause of inaccuracy in formulas. 2500 w. Am Mach—July 27, 1899. No. 28817.

Crane Driving.

Cranes and the Power to Be Used with Them. Mr. Pitt. Read before the Engng. Conference of the Inst. of Civ. Engs., England. Considers self-contained cranes carrying their own motive power, and cranes actuated by power from a separate generator. Discussion. 2700 w. Engr, Lond—June 28, 1899. No. 28435 A.

SPECIAL MOTORS.

Petroleum.

Evolution and Future of Benzine and Petroleum Motors. Georg Lieckfeld. Herr Lieckfeld's second paper shows the evolution of the petroleum motor from the gas engine, and discusses the lines along which it promises to become the motor of the future. 3000 w. Engineering Magazine—August, 1899. No. 28786 B.

Improvements in Four-stroke Petroleum Motors During the Past Ten Years (Verbesserungen des Viertakt Petroleummotors in den Letzen 10 Jahren). Fr. Dopp, jun. A general review of the development of the petroleum motor, with especial reference to the engine designed by the writer. 4000 w. Zeitschr d Ver Deutscher Ing—June 24, 1899. No. 28719 D.

STEAM ENGINEERING.

Boilers.

See Marine and Naval Engineering.

Condensing.

Separate Condensing Plants for Factory Purposes. Alfred Seale Haslam. Read before the Engng. Conference of the Inst. of Civ. Engs., England. Briefly considers the four classes into which the author divides condensers. 2500 w. Engs' Gaz—July, 1899. No. 28587 A.

Connecting Rod.

The Geometric Determination of the Resultant of the External Forces Acting Upon a Connecting Rod (Die Geometrische Bestimmung der Resultaten der auf eine Schubstange Wirkenden Ausseren Kräfte). Prof. Mohr. Giving a simple graphical construction and diagrams showing its application. 1000 w. Zeitschr d Ver Deutscher Ing—July 8, 1899. No. 28725 D.

Cooling Tower.

The Theoretical Treatment of Air Cooling Water Towers. William A. Mosscrop. States the problem to be solved, and illustrates the possibilities of formulas given. 1200 w. Eng News—July 13, 1899. No. 28576.

Feed Water.

Recent Practice in Purifying Feed Water for Locomotives. A summary of the committee report to the Mas. Mechs. Assn., dealing with purification by chemicals, and the treatment of water at pumping stations. 4000 w. Eng News—June 29, 1899. No. 28407.

Fire Box.

Corrugated Fire-Box Sheets for Locomotive Boilers. R. J. O'Neil. From the *Boiler Maker*. Illustrates the method of cupping fire-box sheets used by the Chicago and Alton Ry. 600 w. Eng News—July 13, 1899. No. 28577.

Firing.

See Railway Affairs, Motive Power.

Fuel.

The Economical Use of Fuel. From the presidential address of Mr. George Beilby before the Soc. of Chem. Ind. Shows the magnitude of the problem and discusses the remedies. 1200 w. Col Guard—July 14, 1899. No. 28802 A.

Governors.

The Dynamics of Direct and Continuous-Acting Governors (Dynamik Direct und Continuirlich-Wirkender Regulatoren). C. Koerner. An elaborate mathematical discussion, giving equations for various conditions, and curves showing the governing action. Three articles, 7500 w. Zeitschr d Oesterr Ing u Arch Ver—June 30, July 7, 14, 1899. No. 28729 each B.

Heat Absorption.

The Heat-Absorption Power of Water. G. Halliday. On the circulation in the tubes of water-tube boilers; giving results of experiments. 2000 w. Engr, Lond—July 7, 1899. No. 28640 A.

Heat Exchanges.

Recent Researches Upon the Heat Exchanges Between the Steam and Cylinder-Walls (Der Wärmeaustausch zwischen Dampf und Cylinderwandung nach Neuren Versuchen). A. Bautlin. An elaborate review of the experiments made several years ago by Messrs. Nicolson and Callendar at Montreal. Serial. Part I. 4000 w. Zeitschr d Ver Deutscher Ing—July 1, 1899. No. 28721 D.

Indicator Cards.

See Railway Affairs, Motive Power.

Locomotive Boilers.

See Railway Affairs, Motive Power.

Portable Engines.

Some Trials of Portable Engines. Describes trials carried out on what was practically the same engine under three different conditions and under three different loads, giving results. 5000 w. Mech Wld—June 23, 1899. No. 28425 A.

Purifier.

A New Water-Purifier for the Prevention of Boiler Scale (Ein Neuer Wasserreiniger zur Vollständigen Vermeidung von Kesselstein). Franz Walter. An illustrated description of the Grevenbroich filtering apparatus for boiler feed-water. 2000 w. Oesterr Monatschr f d Oeffent Baudienst—July, 1899. No. 28735 D.

Shocks.

The Action of Shocks in Steam Engines (Stösse und Momente in Dampfmaschinen). J. Meifort. A discussion of the inertia of the reciprocating parts in steam engines, with especial reference to the reduction of vibration in multiple cylinder marine engines. 2500 w. Zeitschr d Ver Deutscher Ing—July 8, 1899. No. 28726 D.

Smoke Prevention.

The Smoke Prevention Legislation in Berlin (Das Bevorstehende Verbot des Schornsteinrauchens in Berlin). W. Häntzschel. A discussion of the proposed legislation by which the production of smoke from chimneys in Berlin is forbidden. 1800 w. Gesundheits-Ingenieur—June 30, 1899. No. 28733 B.

Stay Bolts.

Best Method of Applying Stay Bolts to Locomotive Boilers. Abstract of committee report presented at the annual convention of the Mas. Mechs. Assn. Ill. 2200 w. Eng News—June 29, 1899. No. 28406.

Steam Conduits.

See Architectural Engineering, Heating.

Steam Fittings.

The Arrangement of Steam and Other Pipes and Their Fittings. J. E. Edgcome. Read at the Bristol Convention of the Munic. Elec. Assn. Information from experience, relating to the arrangement of piping for small or moderate sized stations. Ill. 4000 w. Elec Eng, Lond—June 30, 1899. No. 28546 A.

Valve Gear.

Corliss Valves and Gears. The first of a series of articles considering the proportions of Corliss valves, the action of the wrist-plate on the valve movement, etc. Ill. 800 w. Mech Wld—July 7, 1899. Serial. 1st part. No. 28645 A.

Valve Setting.

Setting the Valves of the Buckeye and Rollins Engines. H. H. Kelley. Illustrates and describes the construction giving directions. 2300 w. Engr, U. S. A.—July 15, 1899. No. 28647.

Valves.

An Adjustable Valve Model. Illustrates and describes a locomotive valve model that can be adjusted to the exact size of the valve motion of most any ordinary locomotive. 2200 w. Ry & Engng Rev—July 15, 1899. No. 28613.

MISCELLANY.

Bicycles.

Bicycle Chains. George H. Waltman. Gives illustrated description of the different chains, and their strength as determined by experiment. 1800 w. Mach, N. Y.—July, 1899. No. 28414.

Compressed Air.

Mechanical Applications of Compressed Air. W. L. Saunders. Considers some of the practical applications, its importance in bridge construction, its applications in connection with railroads, etc. Ill. 2000 w. Jour Fr Inst—July, 1899. Serial. 1st part. No. 28485 D.

Compressor.

An Unusual Compressor. Walter K.

Edgar. A criticism of Mr. Wakeman's article on "Operating Ice Machines." 1300 w. Ice & Refrig—July, 1899. No. 28488 C.

Liquid Air.

The Cost of Liquid Air. Frank Richards. Showing that the cost of liquid air is about 5 cts. a gallon as now produced. 1200 w. Am Mach—July 27, 1889. No. 28815.

The Latest Liquid Air Plant. W. C. Peckham. An illustrated description of the interesting plant of the General Liquid Air and Refrigerating Co., of New York, with account of tests. 2500 w. Sci Am—July 15, 1899. No. 28563.

Refrigeration.

Refrigeration in the Brewery. A. F. McClatchey. Describes the process of beer making and the coolers and cooling arrangements. 2500 w. Ice & Refrig—July, 1899. No. 28489 C.

Ventilators.

Helicoidal Ventilators (Ventilateurs Helicoïdes). A. Laponche. A discussion of exhaust fans and ventilating wheels of the turbine form, together with methods of driving by electricity and steam. 2500 w. Génie Civil—June 17, 1899. No. 28701 D.

Waste.

The Utilization of Waste. John Birkinbine. On the importance of utilizing waste products in the industries, noting some applications. Discussion. 3200 w. Pro Engs' Club of Phila—July, 1899. No. 28825 D.

Wire Gun.

The Brown Segmental Tube Wire Gun. Edward A. Gage. Briefly reviews the history of wire-wound guns, and describes the invention of J. H. Brown, and its construction. 4000 w. Jour Worcester Poly Inst—July, 1899. No. 28818 C.

MINING AND METALLURGY

COAL AND COKE.

British Columbia.

Coal Mining in British Columbia. Harrison F. Bulman. Describes the collieries of Crow's Nest Pass and Vancouver Island. 3500 w. Col Guard—June 30, 1899. No. 28555 A.

Cape Colony.

At a Cape Colonial Coal Mine. A statement of the conditions found by the writer at Indwe, in the northeastern portion of the colony. 2300 w. Col Guard—July 7, 1899. No. 28629 A.

Coal Fields.

Coal Fields of Colorado. Arthur Lakes. A description of the different deposits and a consideration of the causes which operated to vary the qualities in different areas. 3300 w. Mines & Min—July, 1899. No. 28506 C.

Some Coal Fields of Puget Sound. Bailey Willis. From the annual report of the U. S. Geol. Survey. Part first considers the location and formation. 1500 w. Ind & Ir—July 7, 1899. Serial. 1st part. No. 28627 A.

The Great Northern Coal Field—Its Rise and Progress. Reviews the history of the collieries in the north of England. Maps. 3700 w. Ir & Coal Trds Rev—July 14, 1899. No. 28804 A.

Coal Sales.

Coal Sales and Contracts. George Johnson. Gives the form of declaration and method of charging for coal conveyed by rail in England. 2000 w. Col Guard—June 23, 1899. No. 28438 A.

Coal Wagons.

Coal Wagon Estimates and Costs. George Johnson. Suggestions to colliery owners who are to build their own wagons. 2000 w. Col Guard—July 7, 1899. No. 28628 A.

Coal Washing.

The Rhymney Coal-Washing Plant. Illustrates and describes a large washing plant recently erected in England. 2700 w. Ir & Coal Trds Rev—June 23, 1899. No. 28431 A.

Coke Furnace.

An Improved Muffle Furnace for Burning Coke. T. Graham Martyn. Read before the Inst. of Min. & Met., London. Longitudinal and transverse sections are given with description and statement of advantages secured. 900 w. Col Guard—June 30, 1899. No. 28552 A.

New Zealand.

Coal Outcrops at the Tangarakau River. Alexander McKay. Report on the district betweeen Stratford and the river named. 1500 w. N. Z. Mines Rec—May 16, 1899. No. 28458 B.

COPPER.

Australia.

Australian Copper. Editorial comment on the boom in copper and its effect on copper mining, especially considering the deposits in Australia. 2500 w. Engng—July 7, 1899. No. 28626 A.

Copper Industry.

The Copper Supply. Editorial review of the copper situation. 1500 w. Ir Age —July 20, 1899. No. 28654.

Ores.

Copper Ores. Arthur Lakes. Description of some of the copper regions of North America, considering the mode of occurrence and the peculiarities of the ores of different mines. 2600 w. Mines & Min—July, 1899. No. 28610 C.

GOLD AND SILVER.

Assaying.

Assaying Telluride Ores for Gold. Richard W. Lodge. Describes experiments with scorification and crucible methods, illustrating points of interest to assayers. 900 w. Tech Quar—June, 1899. No. 28523 E.

British Columbia.

Leech River, Alberni and Skirt Mountain. W. M. Brewer. Report of the camps named. 1600 w. Eng & Min Jour —July 8, 1899. No. 28528.

Colorado.

Resources of the Mount Wilson District, Colorado. Frank L. Nason. An illustrated account of this region very favorable to the advisability of investing, and explaining the conditions to be met. 2300 w. Eng & Min Jour—July 22, 1899. No. 28689.

Copper Plates.

Amalgamated Copper Plates. N. S. Keith. Describes a plan of preparation and treatment that has been found effective and inexpensive as compared with silver plating. 2300 w. Min & Sci Pr—July 1, 1899. No. 28463.

Cyanide.

Notes on the Estimation of Protective Alkali in Cyanide Solutions. Andrew F. Crosse. Describes experiments and the writer's method of determining protective alkali. 1200 w. Jour of Chem & Met Soc of S Africa—May, 1899. No. 28540 E.

Dredging.

Gold Dredging in California. R. H. Postlethwaite. Information of the work in the Feather River, near Oroville, Cal. 1400 w. Min & Sci Pr—July 8, 1899. No. 28566.

Gold Dredging. John M. Sweeney. Illustrated description of devices for obtaining gold from placer deposits with a limited water supply, giving results of experiments and practical trials. 3800 w. Mines & Min—July, 1899. No. 28503 C.

French Guiana.

Gold Mining in French Guiana. E. D. Levat. An account of the prospecting method of working, and peculiarities of the native workers. 1600 w. Eng & Min Jour—July 8, 1899. Serial. 1st part. No. 28529.

Gold Mining.

Fine Gold Mining and Concentration. N. J. Fleck. On the excellent work accomplished with the river burlap machine. 1200 w. Eng & Min Jour—July 15, 1899. No. 28607.

Independence Mine.

How the Independence Mine Was Discovered. T. A. Rickard. An account of the discovery of one of the most valuable gold mines ever uncovered. 1300 w. Eng & Min Jour—July 15, 1899. No. 28606.

Klondike.

The Engineer and the Road to the Gold Fields. Harrington Emerson. A graphic account of the opening of the Yukon and White Pass Route to the Klondike, with many illustrations of the difficult engineering work involved in the construction of the railway. 5000 w. Engineering Magazine—August, 1899. No. 28782 B.

Mexico.

The Mining Camps of El Oro, Mexico. Robert S. Barrett. A descriptive account of a camp which the writer believes is destined to become one of the greatest gold mining camps of the world. 1200 w. Eng & Min Jour—July 22, 1899. No. 28690.

Ore Treatment.

Problems in the Treatment of Butte Ores. A. H. Wethey. Experiments led to the decision to put in a Chilson mill, and grind the jig tailings, treating the reground material on Wilfley machines. These machines are illustrated. 1200 w. Eng & Min Jour—July 1, 1899. No. 28475.

Philippines.

Gold in the Philippines. Ramon Reyes Lala. A brief account of what is thus far known of gold in the Philippines, and the primitive methods used by the natives in its mining and extraction. 2200 w. Am Rev of Revs—July, 1899. No. 28419 C.

Placer Gold.

Gold-Bearing Gravels of the West. Condensed from paper by Alexander McDougall. Illustrates and describes the McDougall plant for placer mining. 1400 w. Min & Sci Pr—July 15, 1899. No. 28666.

Pockets.

Origin and Age of Certain Gold "Pocket" Deposits in Northern California. O. H. Hershey. A statement of what the author considers the correct

theory of the mode of formation. 2000 w. Am Geol—July, 1899. No. 28560 D.

Sampling.

Sampling Placer Deposits. Edmund B. Kirby. Read before the Colorado Scientific Society. On the importance of correct methods of testing their value. 3800 w. Mines & Min—July, 1899. No. 28508 C.

Silver Lead.

The Silver-Lead Deposits of the Slocan, British Columbia. J. D. Kendall. Read before the Inst. of Min. & Met. An interesting illustrated account of this district, which promises to be one of the most important producers of silver-lead ore in the world. 9500 w. Can Min Rev —June 30, 1899. No. 28424 B.

Slimes.

A Continuous Process of Slimes Treatment. Ernest T. Rand. Describes the process and gives some practical results. Ill. 2200 w. Jour of Chem & Met Soc of S. Africa—May, 1899. No. 28541 E.

Transvaal.

The Transvaal Mines and the Boer Government. F. H. Hatch. A timely discussion of the relations of the actual conditions on the Rand, with the engineer's interest in reforms. 2500 w. Engineering Magazine—August, 1899. No. 28785 B.

IRON AND STEEL.

Blast Furnaces.

Blast-Furnace Reactions. Translated from the French of M. E. de Billy. Discusses the action of manganese, silicon, sulphur, phosphorus, arsenic, lead, zinc, copper, etc., in the furnace. 3000 w. Mines & Min—July, 1899. No. 28509 C.

Ingots.

Mold for Steel Ingot. Henry L. Gantt. Specification descriptive of an invention to prevent the ingots from cracking along the surface. Ill. 1600 w. Am Mfr & Ir Wld—July 13, 1899. No. 28602.

Iron Ores.

The Iron Ores of the West Coast. Reviews the history of the ores of the west coast of England, the deposits, cost of production, etc. 1500 w. Ir & Coal Trds Rev—July 14, 1899. No. 28805 A.

Iron Works.

The "Deutscher Kaiser" Company's Iron Works. From *Stahl und Eisen*. Illustrates and describes this recent and extensive construction. 1000 w. Ir & Coal Trds Rev—June 30, 1899. No. 28549 A.

The "Deutscher Kaiser" Iron Works at Bruckhausen on the Rhine (Gewerkschaft "Deutscher Kaiser" in Bruckhausen am Rhein). A general description of this large new works in the Westphalia district with views of the furnaces, and elevation and details of compound blowing engines. 2500 w. 1 plate. Stahl und Eisen—June 15, 1899. No. 28747 D.

MINING.

China.

Mining in Szechuan. A copy of the regulations for the working of mines in this province. 3300 w. U. S. Cons Repts, No. 471—July 8, 1899. No. 28567 D.

Conductors.

Wire Rope Conductors for Pit Cages. John Vaughan. Read before the South Wales Inst. of Engs. Considers this type of conductor exclusively, the difficulties and disturbing elements to be avoided in laying down the plant, manner of putting the ropes into position, etc. Ill. 3000 w. Col Guard—June 30. 1899. No. 28556 A.

Cooling.

Methods of Cooling Overheated Workings in Mines (Vorschläge zur Abkühlung Warmer Betriebspunkte in Grubenbauen). Dr. Tübben. Reviewing the present methods of cooling by sprinkling and by the expansion of compressed air, and suggesting the use of liquid air. 1200 w. Glückauf—July 8, 1899. No. 28756 B.

Electricity.

Electricity in Coal Mining—John Price Jackson and Frank F. Thompson. Presented at Boston meeting of the Am. Inst. of Elec. Engs. Refers especially to the mining of soft coal, considering systems for lighting, haulage, cutting or drilling, pumping, and driving fans. 3000 w. Elec, N. Y.—July 12, 1899.—No. 28561.

Firedamp.

The Testing Gallery at the Maria Coal Mine at Höngen (Die Versuchsstrecke auf der Steinkohlengrube Maria bei Höngen). An illustrated account of the plant at Höngen, in the Aachen district, for testing the explosive character of mine gases. 1500 w. 1 plate. Glückauf—July 1, 1899. No. 28755 B.

Haulage.

Modern Mine Haulage Practice. Harry K. Myers. Describes the most modern methods used in the coal mines of the United States, illustrating various mining locomotives. 4000 w. Pro Engs' Club of Phila—July, 1899. No. 28824 D.

Head Frames.

Steel Head Frames for Mines. George S. Binckley. Illustrates types of frames, pointing out their defects, and describing designs based on correct principles. 2800 w. Min & Sci Pr—July 22, 1899. No. 28828.

Hoist.

Combined Gravity and Power Hoist. A. W. Evans. A description of a unique plant for transporting coal at the mines of the New Soddy Coal Company. Ill. 2000 w. Mines & Min—July, 1899. No. 28502 C.

Mine Fires.

Extinguishing Mine Fires. Frank Pardee. Describes two successful methods employed in dealing with mine fires in anthracite coal mines. 1600 w. Mines & Min—July, 1899. No. 28504 C.

Mine Fire. H. Burrell. Describes successful methods employed in extinguishing an underground fire at Diamondville, Wyoming. 800 w. Mines & Min—July, 1899. No. 28505 C.

Pumping.

Pumping Machinery. R. S. B. On the necessity of some system of surveillance over the operation and working of mining plants, especially the pumping arrangements. 1300 w. Col Guard—June 23, 1899. No. 28437 A.

Pumps.

Pumps for Prospectors and Small Mines. F. W. Van Ness. States the conditions required in such pumps, and briefly discusses some on the market. 800 w. Eng & Min Jour—July 8, 1899. No. 28527.

Shaft.

Repairing the Lining of Shaft No. 1 of the Gneisenau Mine at Derne (Reparatur der Cuvelage des Schachtes I der Zeche Gneisenau dei Derne). F. Schulte. Describing the manner in which the cast-iron lining of the shaft was reinforced by an inner lining for a portion of its length. 1500 w. 1 plate. Glückauf—June 17, 1899. No. 28753 B.

Shot Firing.

Progress in the Electric Firing of Mine Shots. From a communication by Bergassessor Heise to *Glückauf*. Gives an idea of the progress made by electric ignition during the last two years, illustrating and describing apparatus. 3500 w. Col Guard—July 7, 1899. No. 28630 A.

Sweden.

Mining Practice in Sweden (Ueber Schwedische Bergbaubetriebe). Josef Mauerhofer. Describing especially the methods employed in mining and handling the iron ores of Northern Sweden. Serial. Part I. 2500 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—July 1, 1899. No. 28752 B.

Tubbing.

Description of Tubbing Shafts Against Water. R. Clive. Prize essay of the British Soc. of Min. Students. An illustrated description of the tubbing of two shafts and the method of putting it in. 2000 w. Ir & Coal Trds Rev—July 7, 1899. No. 28632 A.

Ventilation.

Forced Ventilation Plants (Ueber Blasend Wirkende Hauptventilator-Anlagen). A discussion, by Bergassessor Kette, of the relative merits of forced and exhaust ventilation for mines. The use of underground blowers to force the air out of the mine, is advocated. 4500 w. Glückauf—June 24, 1899. No. 28754 B.

Winding.

An Endless Chain Winding Plant. T. A. O'Donahue. Read before the South Wales Inst. of Engs. Describes the method of winding at Rowley Colliery, and discusses the advantages. Ill. 1700 w. Col. Guard—June 30, 1899. No. 28554 A.

MISCELLANY.

Calciner.

The Latest Type of Mechanical Calciner. W. Blackmore. Describes the Godfrey mechanical calciner, giving a vertical section, and a report of cost as compared with other methods. 1800 w. Col Guard—June 30, 1899. No. 28553 A.

Diamonds.

The Diamond Fields of Brazil. Extracts from the U. S. Cons. Rept. of Minister Bryan, describing the various kinds of diamond mining. 2500 w. Stone—July, 1899. No. 28822 C.

Mica.

The Occurrence of Mica in South Norway. J. F. Wells. Read before the Inst. of Min. & Met. Describes the mine and the deposit. Ill. 1500 w. Col Guard—July 7, 1899. No. 28631 A.

Minerals.

Feldspars and Kaolins of Southeastern Pennsylvania. T. C. Hopkins. Information based on field work, describing the mode of occurrence, method of quarrying, uses, origin, etc. 9500 w. Jour Fr Inst—July, 1899. No. 28484 D.

Petroleum.

The Fire Danger from Petroleum (Ueber die Feuergefährlichkeit des Petroleums). E. Priwoznik. A discussion of the safe fire-tests for various petroleums, giving the practice in different countries, and the statutes regulating the subject in Austria. Two articles, 3000 w. Oesterr Zeitschr f Berg u Hüttenwesen—June 24, July 1, 1899. No. 28751 each B.

Porto Rico.

Porto Rico. Manuel Victor Domenech. Describes the physical characteristics of the country and gives what is known of the undeveloped mineral deposits, which

promise to be valuable. 4000 w. Mines & Min—July, 1899. No. 28501 C.

Quarrying.

The Bluestone Industry of New York. James B. Gordon. Remarks on the changes in recent years, which led to the quarrying of thicker and larger stones, and necessary changes in methods, with an illustrated description of quarries and account of the deposits in New York State. 3400 w. Stone—July, 1899. No. 28821 C.

Riot.

The Cœur d'Alene Riot. An explanation of the troubles at Kellogg, Idaho, which resulted in the blowing up of the Bunker Hill and Sullivan concentrator. Ill. 1200 w. Mines & Min—July, 1899. No. 28507 C.

Zinc Extraction.

The Electrolytic Methods of Zinc Extraction. John B. C. Kershaw. Gives a summary of the processes which have received or are now receiving industrial trial, with opinions relative to the economic aspects. 1700 w. Elec Rev, Lond—July 7, 1899. Serial. 1st part. No. 28619 A.

RAILWAY AFFAIRS

CONDUCTING TRANSPORTATION.

Accidents.

Comparative Notes on the Statistics of Accidents (Vergleichende Betrachtungen zur Unfallstatistik). A discussion by Herr Blum of the statistics of railway accidents in Prussia for 1807, plotted in comparative curves with those of other European railways. 4500 w. Glaser's Annalen—June 15, 1899. No. 28737 D.

Train Accidents in the United States in May. Detailed list with classified summary and remarks. 4400 w. R R Gaz—July 14, 1899. No. 28583.

Australian Railways.

Government Ownership of Railways in Australia. Extract from the Seattle *Post-Intelligencer*. Information given by a citizen of Sydney, N. S. W., very unfavorable to government operation. 1400 w. Ry & Engng Rev—July 1, 1899. No. 28470.

Master Mechanics' Association.

Meeting of the American Railway Master Mechanics' Association. A general report of the meeting, topical discussions, etc. 11700 w. R R Gaz—June 30, 1899. No. 28415.

Rules.

The Standard Code on the New York, New Haven & Hartford. Comments on the new rules just put in use on all of the 20 divisions of this road. 2000 w. R R Gaz—July 14, 1899. No. 28580.

LEGAL.

Connecticut.

Railroad Interests in the Connecticut Legislature. Clarence Deming. A statement of legislation affecting the steam and trolley interests in the state. 2500 w. R R Gaz—July 28, 1899. No. 28844.

MOTIVE POWER AND EQUIPMENT.

Air Brakes.

The Effect of the Air Brake Decision. Editorial discussing the decision in the case of the Westinghouse Air Brake Co. against the New York Air Brake Co. 2000 w. R R Gaz—July 28, 1899. No. 28849.

Car Lighting.

Lighting Railway Carriages by Electricity. Describes and illustrates Stone's apparatus as applied to the Metropolitan railway carriages. 2200 w. Engr, Lond—July 14, 1899. No. 28801 A.

Coal Cars.

New 100,000 Lbs. Capacity Coal Cars of the Norfolk & Western. Illustrates and describes an interesting hopper bottom coal car with a steel underframe. 800 w. R R Gaz—July 28, 1899. No. 28845.

Couplers.

Automatic Couplers on American Freight Cars. Reviews the history, development and present conditions of automatic couplings in the United States. Ill. 3500 w. Engr, Lond—July 7, 1899. Serial. 1st part. No. 28633 A.

The M. C. B. Coupler. The committee report to the Master Car Builders' Assn., proposing new contour lines and new specifications. Ill. 7800 w. R R Car Jour—July, 1899. No. 28491.

English Cars.

Large Capacity English Cars. Detail drawings of a 50-ton capacity goods wagon for iron ore service on the Caledonian Railway. 300 w. Ry Age—July 21, 1899. No. 28692.

Fire Box.

See Mechanical Engineering, Steam Engineering.

Firing.

Economical Locomotive Firing. K. P. Alexander. Abstract of paper prepared for the St. Louis Ry. Club. Suggestions to promote economy, advising a traveling

engineer competent to instruct the firemen. 900 w. Ry & Engng Rev—July 8, 1899. No. 28535.

Indicator Cards.

Locating the Cut-Off and Other Events on Locomotive Indicator Cards. C. H. Robertson. Illustrates and describes the practice of the author in locating points named. 1500 w. R R Gaz—June 30, 1899. No. 28416.

Locomotive Boilers.

Locomotive Boilers—Some Points to Be Thought of When Getting Them. H. Wade Hibbard. Discussing recent designs of boilers and boiler-shop methods. Followed by general discussion. 12000 w. N. Y. R R Club—May 18, 1899. No. 28608.

Locomotives.

American Locomotives for the Midland Railway. Drawings and dimensions of these engines, with statement of the conditions stipulated. 800 w. Engng—July 7, 1899. No. 28625 A.

Atlantic Type Locomotive—Class E-1, No. 698. Illustrated description with dimensions of an unusually interesting engine built for the West Jersey and Seashore Div. of the Pennsylvania Railroad. 600 w. R R Gaz—July 7, 1899. No. 28497.

English and American Locomotive Building. Charles Rous-Marten. Mr. Rous-Marten's second paper contains a comparison of the salient differences in design and construction between English and American engines, and numerous views in English and American works. 5000 w. Engineering Magazine—August, 1899. No. 28784 B.

Fast Passenger Locomotives on the Pennsylvania Railroad in 1850. Illustrates and describes three locomotives of the "Crampton" type. 1300 w. R R Gaz—July 28, 1899. No. 28850.

Goods Engine, Furness Railway. Illustrations showing sections and a general external view of this six-wheeled coupled goods engine, with dimensions. 500 w. Engr, Lond—July 7, 1899. No. 28635 A.

Handling the Richmond Compound. Robert Rennie. Calls attention to the operation of the valves and the care and lubrication needed. 1200 w. Loc Engng—July, 1899. No. 28410 C.

Heavy Freight Locomotives for the Lehigh Valley R. R. Illustrated detailed description, giving dimensions. 1000 w. Eng News—July 27, 1899. No. 28833.

Pennsylvania Railroad Class H-6 Locomotives. An outline in detail of the new features of these engines, with drawings and dimensions. 600 w. R R Gaz—July 14. 1899. No. 28581.

Schenectady Consolidation Locomotives for the D. & H. Engraving and descriptive specifications. 350 w. R R Gaz—July 28, 1899. No. 28848.

60-Ton Heisler Geared Locomotive: McCloud River R. R., Northern California. Particulars of an engine having three driving trucks, or twelve driving wheels, which has been in service some time. 900 w. Eng News—July 27, 1899. No. 28835.

Ten-Wheel Passenger Locomotives for the Denver and Rio Grande R. R. Illustration and principal dimensions. 500 w. R R Gaz—July 28, 1899. No. 28847.

The First Engines Built at Crewe. Clement E. Stratton. An account of engines completed in 1842, with interesting information relating to them. 1800 w. Mech Wld—July 7, 1899. No. 28646 A.

Passenger Coach.

Metal-Plating for Passenger Coach. Illustrates and describes a car in which each piece of wood is covered with sheet copper in such a manner that the metal fits into and around the conformations. 500 w. Ry & Engng Rev—July 22, 1899. No. 28693.

Rolling Stock.

The Rolling Stock of the Great Central Railway, England. The first of a series of illustrations and detailed descriptions of the accommodations for passenger traffic. The present article is merely a brief introduction, with illustrations of elevation and under frame plan. 250 w. Engng—July 14, 1899. Serial. 1st part. No. 28695 A.

Stay Bolts.

See Mechanical Engineering, Steam Engineering.

NEW PROJECTS.

Railroad Changes.

The Boston and Albany and the Central. Editorial comment on the agreement by which the B. & A. passes into the ownership and control of the N. Y. Central. 1200 w. R R Gaz—July 7, 1899. No. 28499.

Railway Development.

The World's Railways and Iron and Steel Requirements. Part first discusses the railway prospects of Africa, giving maps. 2800 w. Ir & Coal Trds Rev—June 30, 1899. Serial. 1st part. No. 28548 A.

South America.

An American Railway in Colombia. Francis R. Hart. Gives a brief outline of the history of Colombia and the physical characteristics of the country and describes the terminal works, railway, and line of steamboats owned and managed

by an American corporation. Ill. 4300 w. Tech Quar—June, 1899. No. 28521 E.

Tehuantepec Railway.

The Tehuantepec Railway Across the Isthmus of Mexico. Reviews the history of the road and the work to be done before it is opened for traffic. 1200 w. Transport—July 14, 1899. No. 28688.

PERMANENT WAY AND FIXTURES.

Boston Station.

The Boston Southern Station. J. P. Coleman. Continuation of an article published May 12. The present article describes the electro-pneumatic interlocking, giving diagram of switches and signals, and general views. 2700 w. R R Gaz—July 21, 1899. No. 28670.

Coal Dock.

Coal Dock Plant of the Baltimore and Ohio Ry., Sandusky, Ohio. A description of the plant and its operation. Ill. 700 w. Ry & Engng Rev—July 1, 1899. No. 28469.

Earth-Slips.

Causes of Earth-Slips in the Slopes of Cuttings and Embankments of Railways, and How to Prevent or Remedy Them. Robert Elliott. Read before the Engng. Conference of the Inst. of Civ. Engs., England. A brief consideration of the topics named. 1600 w. Engr, Lond—June 23, 1899. No. 28433 A.

Gage Widening.

Change of Gage on the Columbia and Western Ry. An account of the work of widening the gage without interrupting traffic. 700 w. Ry & Engng Rev—July 15, 1899. No. 28614.

Klondike.

See Mining and Metallurgy, Gold.

Paris.

The Extension Works of the Station of the Eastern Railway of France (Les Travaux d'Agrandissement de la Gare de l'Est). G. Leugny. With plans and views of the extension works now in progress in view of the increased travel anticipated during the Paris Exposition. 2000 w. Revue Technique—July 10, 1899. No. 28709 D.

The New Lines of the Western Railway of France (Les Nouvelles Lignes de la Compagnie des Chemins de Fer de l'Ouest). A description of the new connections made by the absorption of some local railways by the Western Railway of France together with the new construction work now in hand in and about Paris. 3500 w. Rev Gen des Chemins de Fer—June, 1899. No. 28717 G.

The Prolongation of the Orleans Railway in Paris (Le Prolongement de la Ligne d'Orleans dans Paris). E. Dieudonné. With numerous views of the present state of the work from the Place Vallmbert to the Quai d'Orsay, and a plan of the new terminal station. 4000 w. 1 plate. Revue Technique—June 25, 1899. No. 28706 D.

Railroad Stores.

A New Method of Keeping Track of Railroad Stores. Explains the method used by the Illinois Central Railroad at the Burnside shops, Chicago. 1000 w. Ry & Engng Rev—July 8, 1899. No. 28534.

Relaying Railways.

The Most Expeditious Method of Relaying the Railways of This Country, Involving the Least Interruption of Traffic, Having Regard to Safety and Economy. Harry Footner. Read before the Engng. Conference of the Inst. of Civ. Engs., England. Classifies and discusses methods. 1400 w. Engr, Lond—June 23, 1899. No. 28432 A.

Shed Extension.

Moving a Great Steel Arch. Illustrates and describes the work of moving a pair of steel arches weighing 300 tons, in the shed extension of the Pennsylvania Railroad depot in Jersey City. 700 w. Ir Age—July 20, 1899. No. 28653.

Signals.

The Bouré Locking System (Les Surrures d'Enclenchement du Système Bouré). M. A. Moutier. A very complete account of the Bouré system of locks and keys for the prevention of tampering with railway signals, as employed on the Northern Railway of France. 20,000 w. Rev Gen des Chemins de Fer—June, 1899. No. 28718 G.

Sleepers.

Comparative Trials on Metallic Sleepers (Essais Comparatifs de Traverses Metalliques). Ch. Renson. A review of the results obtained with various types of metallic cross-ties on the Liége-Limburg Railway between 1881 and 1898. Two articles, 6000 w. Schweizerische Bauzeitung—June 10, 17, 1899. No. 28742 each B.

Station.

The New Railway Station at Tours (La Nouvelle Gare de Tours). A fully illustrated account of this handsome new French railway station, with plan of the approaches, and details of the construction. 2500 w. 1 plate. Génie Civil—June 24, 1899. No. 28702 D.

Telephones.

The Telephone in Railroad Service. George W. Blodgett. Considers requirements for sending important railroad

messages by telephone. 1500 w. R R Gaz—July 28, 1899. No. 28846.

Terminal.

Southern Pacific Terminal at Oakland. Illustrates and describes the recently rearranged and improved station. 600 w. R R Gaz—July 21, 1899. No. 28672.

Tunnel Ventilation.

The Ventilation of the St. Gothard Tunnel. At first natural ventilation of this tunnel proved sufficient, but increased traffic made necessary artificial ventilation. The means adopted to secure the desired results are here described. 1000 w. Engng—June 30, 1899. No. 28551 A.

The Ventilation Plant for the St. Gothard Tunnel (Ventilations-Anlage für den Gotthard-Tunnel). A description of the Saccardo ventilating system as installed at Göschenen for forcing air through the St. Gothard tunnel. 3500 w. Schweizerische Bauzeitung—June 17, 1899. No. 28744 B.

Ventilation of the St. Gothard Tunnel. Editorial on the condition of the air in this tunnel, and the means recently adopted to effect a change of air, which has thus far proved effective. 1000 w. R R Gaz—July 14, 1899. No. 28582.

TRAFFIC.

Freight.

The Right to Route Your Freight. Editorial on an interesting decision of the Supreme Court of Tennessee. 3500 w. R R Gaz—June 30, 1899. No. 28417.

Railway Statistics.

Statistics of Railways in the United States for the year ending June 30, 1898. Advance abstract of the forthcoming Interstate Commerce Commission report. 900 w. Eng News—July 20, 1899. No. 28676.

Rates.

The Texas Railway Commission and Railway Rate Discriminations. Editorial discussion of the revelations brought out by the railway commission of Texas in regard to free transportation, rebates, etc. 1700 w. Eng News—July 6, 1899. No. 28456.

The Ton-Mile Rate and a Great Consolidation. Editorial discussion of the principles affecting rate averages, considering the ton-mile average from the point of view of the railroad stockholder. 2000 w. R R Gaz—July 21, 1899. No. 28673.

STREET AND ELECTRIC TRAMWAYS

Accumulators.

Accumulator Driving on the Electric Street-Railway in Ghent (Akkumulatorenbetrieb der Elektrischen Strassenbahn zu Ghent). J. Zacharias. With a general description of the method of charging the batteries, and details of the working of the plant. There are 38 motor cars and 22 miles of track. 1500 w. Elektrotech Zeitschr—July 6, 1899. No. 28769 B.

Boosters.

Boosters in Street Railway Service. M. C. Canfield. Explains what a booster is and its use. 1600 w. Engr, U. S. A.—July 1, 1899. No. 28466.

Boston Elevated.

Building the Boston Elevated. Edgar M. Smith. Views showing details of foundation work on the Charlestown Division are given, and the difficulties are explained. 1300 w. R R Gaz—July 7, 1899. No. 28498.

The Feeder System of the Boston Elevated Railway. H. W. Weller. An illustrated description of the system and matters connected with it, with some of the methods adopted to obtain the most economical results. 3800 w. Ry Wld—July 6, 1899. No. 28664 A.

Brazil.

The New Railway, Light and Power Enterprise in Sao Paulo, Brazil. Brief illustrated description, with information of this city directly under the tropic of Capricorn. 1400 w. St Ry Jour—July, 1899. No. 28479 D.

Cairo.

The Cairo Electric Tramways. Illustrated description of the line and its equipment, with views on the route. 900 w. Ry Wld—July 6, 1899. No. 28665 A.

Corea.

The Electric Railway in Seoul. An intersting illustrated account of the opening of an electric railway in the capital of Corea. 800 w. Ry Age—July 21, 1899. No. 28691.

Düsseldorf.

The Electric Light-Railway Between Düsseldorf and Krefeld. Abbreviation of a paper by Gustav Braun, published in the *Elektrotechnische Zeitschrift*. An illustrated detailed description of a railway of interest on account of its high-speed working, and the deviation from ordinary practice in its construction. 2800 w. Elec Eng, Lond—July 7, 1899. Serial. 1st part. No. 28643 A.

The Electric Railway Between Düsseldorf and Krefeld (Die Elektrische Kleinbahn Düsseldorf-Krefeld). Gustav Braun. A fully illustrated description of this recently opened road, which passes over the new Rhine bridge at Düsseldorf, and which is used both for passenger and merchandise. 7000 w. Elektrotech Zeitschr—June 22, 1899. No. 28760 B.

Electric Traction.

Electric Traction on Tramways. J. Clifton Robinson. Extracts from paper read before Cleveland Inst. of Civ. Engs. at Stockton-on-Tees, England. Relates to the tramways of Bristol, Dublin, Middlesborough, Stockton and Thornaby, and the London United tramways. 5000 w. St Ry Jour—July, 1899. No. 28482 D.

Electrolysis.

Electrolysis at Yonkers, N. Y. Information from report of A. A. Knudson. Describes the serious condition of the water mains, detected by electric measurements. 500 w. Eng Rec—July 1, 1899. No. 28446.

Granite Tramways.

The Heytor Granite Tramway. W. B. Paley. An account of a unique railroad in the west of England, built in 1820 by a private individual. 900 w. R R Gaz—July 21, 1899. No. 28671.

Hull.

The Hull Electrical Tramways. Historical account and illustrated description. 3800 w. Elec Rev, Lond—July 7, 1899. No. 28617 A.

Hungary.

The Light Railways of Hungary in 1897 (Die Ungarischen Kleinbahnen in Jahre, 1897). Rudolf Nagel. A tabulated review of street and electric tramways and light suburban railways, giving the traffic earnings, and operative data. 2000 w. Glaser's Annalen—No. 28741 D.

Kingston.

The Street Railway System of Kingston, Jamaica. Henry E. Raymond. Illustrates and describes an example of high grade hydraulic and electric engineering in the West Indies. 2000 w. Am Elect'n—July, 1899. No. 28493.

Louisville, Ky.

Power Station and Shops of the Louisville Railway Co. Illustrates and describes the electrical repair shop and its branches, also the power house. 1400 w. St Ry Jour—July 15, 1899. No. 28667 C.

Multiple-Unit System.

The Problem of Elevated and Suburban Electric Railway Transportation. Frank J. Sprague. Abstract of a lecture read before the Am. Inst. of Elec. Engs. Sets forth the advantages of the multiple unit system, giving results on the Southside Elevated of Chicago. Also an interesting chronology of modern electric railroad operation. 10500 w. St Ry Jour—July, 1899. No. 28481 D.

Municipal Ownership.

Decision in the Detroit Case. Text of the decision of the Supreme Court of Michigan holding the law providing for municipal ownership of Detroit street railways to be unconstitutional. 8000 w. St Ry Rev—July 15, 1899. No. 28669 C.

Niagara Gorge.

Building the Niagara Gorge Railway. George A. Ricker. An account of the business side of the enterprise, with illustrations of the route, and description of the construction. 5500 w. Pro Engs' Club of Phila—July, 1899. No. 28826 D.

Overhead.

Overhead Construction for Electric Tramways (Oberleitungsmaterial für Elektrische Bahnen). A general description of the connections, insulators, supports, and details of overhead trolley construction as used by the *Allgemeinen Elektricitätsgesellschaft* of Berlin. 5000 w. Elektrotech Zeitschr—July 13, 1899. No. 28770 B.

Pittsburg Tramways.

System of the United Traction Company, Pittsburg. Illustrated detailed description of the consolidated roads and their equipment. 3000 w. St Ry Jour—July, 1899. No. 28477 D.

Power Station.

Power Station of the Northwestern Elevated Railway of Chicago. Illustrates and describes a plant nearing completion. 1400 w. St Ry Jour—July, 1899. No. 28480 D.

Shops.

Shops of the Consolidated Traction Co., Pittsburg, Pa. Illustrated detailed description of finely equipped shops. 3400 w. St Ry Rev—July 15, 1899. No. 28668 C.

Track Construction.

Track Construction of the Cincinnati Street Railway Company. A report on the construction that has had five years' wear, and changes made in power. Ill. 1200 w. St Ry Jour—July, 1899. No. 28478 D.

NEW CATALOGUES AND TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine when you write.

Cole, Marchent & Morley, Bradford, England—Illustrated catalogue of steam engines and condensing plant, describing the construction in detail. A well got-up booklet. Useful information for engineers is also given.

Humpidge, Holborow & Co., Ltd., Dudbridge Iron Works, Stroud, Glos., England.—*(a)* Illustrated price list of the "Dudbridge" gas engine with large number of testimonials from users; *(b)* Price list of Dudbridge oil engines with statement of advantages claimed.

The British Bundy Co., 81, Southwark St., London, S. E.—*(a)* Pamphlet entitled "Leaks," showing the economies to be effected by the use of the Bundy Time Recorder; *(b)* List of users of the Bundy Recorder; *(c)* Testimonials from users. All these pamphlets are got up in a very artistic style.

A. A. Rickaby, Bloomfield Engine Works, Monkwearmouth, Sunderland, England.—Price list of engineers' supplies, packings, piston rings, etc.

P. & W. MacLellan, Ltd., 129, Trongate, Glasgow, Scotland.—Catalogue (Section I.) embracing machinery for lifting weights by hand, steam, electric, or hydraulic power; and illustrating and describing such appliances from a pulley block to a locomotive, winding engine or heavy crane. Portable railways and heavy rolling stock are also included.

The Harrisburg Foundry and Machine Works, Harrisburg, Pa., U. S. A.—Handsome catalogue describing the system of steam engines made by the concern, as well as other products, including boilers, furnaces and road-rollers. A copy of the *edition de luxe* of the same catalogue has also been received, handsomely bound and ornamented, for special distribution.

The Chisholm & Moore Manufacturing Co., Cleveland, Ohio, U. S. A.—Catalogue of chain hoists operated by pneumatic, electric, and hand power, also of pneumatic cranes, and of trolleys for use with chain hoists.

The Winslow Bros. Co., Chicago, Ill., U. S. A.—Portfolio catalogue containing reproductions of bronze decorative work, including gates, mausoleum doors, panels, tablets, etc., the whole forming a remarkably handsome collection both as regards the original subjects and the manner of their presentation.

Baldwin Locomotive Works, Philadelphia, Pa., U. S. A.—Record of recent construction, No. 13, containing numerous valuable diagrams for the determination of piston speeds, tractive power, speed resistance, hauling capacity, etc., together with the formulas from which the diagrams have been constructed and instructions as to their use. The whole forms a valuable collection of information having the practical endorsement of the firm by which it is issued.

P. R. Jackson & Co., Ltd., Manchester, England.—Complete catalogue, listing a large line of steel castings and forgings, moulded gears, etc.; also electrical equipment, such as motors, dynamos, electric hauling, winding and pumping plants for mines, arc lamps, etc. Fully illustrated with views of works. A very valuable catalogue.

The Kingfisher Patent Manufacturing Co., Leeds, England.—Series of price lists of lubricants, anti-fouling compositions, boiler liquors, etc.

John Langfield & Co., 11, Blackfriars St., Manchester.—Pamphlet describing Langfield's "Moist Air" heating and ventilating apparatus, with list of users. Illustrated.

The Rankine Patent Feed Water Filters Co., Ltd., Victoria St., London.—Circulars describing feed water filters of various types. A type of filter with double filtration is also described. Illustrated.

Isaac Storey & Sons, Manchester, England.—*(a)* Series of sheets, pricing gun metal fittings, gauges, valves, lubricators, etc.; *(b)* catalogue of Proell's automatic expansion apparatus, the Proell Corliss engine, and Proell's spring governor. Full particulars; *(c)* Pamphlet entitled "Shall We Use Proell's Automatic Expansion Apparatus?"

John Lang & Sons, Johnstone, Glasgow, Scotland.—Lathe catalogue describing all types in general use; also gear cuting machines and other tools. Fully illustrated.

Merchant & Co., Philadelphia, Pa., U. S. A.—Small pamphlet describing the improved method of dipping tin plate adopted by the firm for the purpose of insuring a uniform thickness of tin coating over the entire surface.

Fraser & Chalmers, Chicago, Ill., U. S. A.—Catalogue No. 3, Fourth Edition, devoted to methods and machinery for roasting, smelting, and refining, for gold, silver, lead, and copper. Numerous illustrations and plans of standard appliances are given, together with useful information as to methods of work.

The Snider-Hughes Co., Cleveland, Ohio, U. S. A.—General Catalogue No. 11, of steam pumps, high-duty pumping engines, hydraulic machinery, air compressors, and air-lift plants; with illustrations and specifications of the different machines, and a number of useful tables of the properties of water and steam.

Webster, Michelson & Co., Eve Hill Works, Dudley, England.—Circular describing and pricing dynamos and copper gauze brushes.

T. W. Palmer & Co., 5, Victoria St., London, S. W.—Price list of steel wire fencing of various kinds; galvanized netting; continuous iron corrugated rail fencing, etc. Wrought iron entrance gates are also illustrated and priced, as well as corrugated iron buildings.

United Flexible Metallic Tubing Co., 112, Queen Victoria St., London.—Circular price list of flexible metallic tubing.

The Electrical Co., Ltd., Charing Cross Road, London, W. C.—Series of illustrated catalogues and price lists of *(a)* Dynamos and electric motors; *(b)* Luna arc lamps and accessories; *(c)* Switches and wall plugs; *(d)* Knife switches; *(e)* Lamp Holders; *(f)* Accumulator apparatus; *(g)* Measuring and testing instruments; *(h)* Ceiling roses, fuse wire, etc.; *(j)* Carbons for arc lamps; *(k)* Incandescent lamps; *(l)* Heating and cooking apparatus.

Geo. Richards & Co., Ltd., Broadheath, near Manchester, England.—Illustrated catalogue *(a)* of pulleys, hangers, shafting couplings and other mill fittings; *(b)* Wood working machinery with particulars of a full line of tools. Prices are given.

The McConway & Torley Co., Pittsburgh, Pa., U. S. A.—Handsomely bound catalogue of the Janney coupler, for passenger cars, freight cars, and locomotives. Plates of all the various parts are given, together with lists of pieces by number, and a very complete index, rendering the catalogue most valuable for reference.

The Ball Bearing Co., Boston, Mass., U. S. A.—Catalogue of ball and roller bearings for all kinds of machine construction, shafting and vehicles, with price lists and telegraph codes.

The Barber Asphalt Paving Co., New York.—Descriptive catalogue of genuine Trinidad lake asphalt pavements, with many illustrations of asphalt paved streets in various cities, together with maps and lists of streets in the principal cities of the United States, showing the extent to which asphalt pavements have been introduced.

New York Central and Hudson River Railroad, New York.—Four Track Series, No. 10. Pamphlet descriptive of the attractions of the Thousand Islands and the St. Lawrence river, with map and much general information.

The British Luxfer Prism Syndicate, Ltd., 16, Hill St., Finsbury, London.—*(a)* Illustrated manual of "Luxfer Prisms" and Electric Glass, being a short treatise on the introduction of light to buildings by the aid of this device. The information is of considerable interest; *(b)* Pamphlet entitled "Fire-Resisting Window Glass," which states the advantages of Electro-glass.

Thomas Larmuth & Co., Salford, Manchester, England.—Catalogue of the "Hirnant" mining machinery, giving particulars of air compressors, rock drills and other mining plant; a description of a shaft sinking carriage is also given. Fully illustrated, also prices.

Victor Coates & Co., Ltd., Lagan Foundry, Belfast, Ireland.—*(a)* Illustrated catalogue of Engines, boilers and cranes, with prices and code for ordering. Particulars of machinery for the tobacco, malting and other trades are also given; *(b)* Abridged edition of the above catalogue.

Samuel Denison & Son, Hunslet Foundry, Leeds, England.—Catalogue of scales, weighing machines and weighbridges, with prices and illustrations. Two new wire testing machines for fine wire are also illustrated.

Charles E. Billin & Co., Chicago, Ill., U. S. A.—General catalogue of machinery and supplies for mines and mills, being pages 485 to 572 of the general serial catalogue issued by this firm, and containing, in addition to the goods listed, extracts from various sources of information in regard to mining machinery and appliances.

Electric Storage Battery Co., Philadelphia, Pa., U. S. A.—Illustrated pamphlet describing the installation of chloride accumulators in the criminal court building, New York City; with diagram showing the manner in which the battery assists in equalizing the load upon the engine.

The Bullock Electric Co., Cincinnati, Ohio, U. S. A.—Handsomely illustrated catalogue of Bullock electric generators and motors, with examples of numerous applications of electric driving by direct connection to various machine tools and other machinery.

Rand Drill Co., New York.—Advance sheets of 1899 catalogue, illustrating and describing air and gas compressors, with many illustrations of existing installations, and tabulated information concerning numerous styles and sizes of compressors.

Latch & Batchelor, Ltd., Hay Mills, Birmingham, England.—Circular describing and showing sections of "flattened strand" wire ropes, with list of sizes and breaking strains.

Schattner & Co., Timberhill, Norwich, England.—Circular describing the "Long Schattner" prepayment meter for electricity.

W. N. Brunton & Son, Wire Works, Musselburgh, Scotland.—Price list of wire, with breaking strains and other data; also of springs of coppered steel, and galvanized and tinned iron work.

E. & J. Richardson, Elswick Leather Works, Newcastle-on-Tyne, England.—Price list of leather belting.

The Campbell Gas Engine Co., Ltd., Halifax, England.—Catalogue of the Campbell oil engine and ram pumps; also long list of testimonials from users. Fully illustrated.

Flather & Son, Park Electrical Works, Leeds.—Price list of continuous current dynamos and motors of the multipolar type.

Waterbury Rope Co., New York.—Pamphlet catalogue about rope and rope-making, with especial reference to rope for transmission and hoisting. An account of the gathering of the material and processes of manufacture is given, together with useful information concerning weights and strength of various sizes.

Pittsburgh Feed-Water Heater Co., Pittsburgh, Pa., U. S. A.—Catalogue of Pittsburgh feed-water heaters, both open and closed, with descriptions of the different types, and numerous testimonials from users.

Westinghouse Electric & Mfg. Co., Pittsburgh, Pa., U. S. A.—Detail catalogues *(a)* of the West-

inghouse direct-current fan motor; *(b)* of the Westinghouse alternating-current fan motors; and *(c)* of the Wurts non-arcing lightning arresters.

The Winton Motor Carriage Co., Cleveland, Ohio, U. S. A.—Neat pamphlet containing an account of the recent trip of a Winton motor carriage from Cleveland to New York, a distance of more than 700 miles. An illustrated description and price-list of the various types of Winton vehicles is appended.

The Edison & Swan United Electric Light Co., Ltd., 36, Queen Street, London, E. C.—Illustrated catalogues as follows: Sections 1 and 2, Incandescent Lamps. Section III., Electric light fittings of all descriptions. Section IV., Fittings, (Supplementary list). Section VII., Dynamos, alternators, transformers, etc. Section IX., Glass, silk and paper shades and globes. These sections together form a very large and complete catalogue of electric lighting requisites.

Walter Newbold & Co., 28, Gracechurch St., London, E. C.—Catalogue of machine tools, including all usual types, with prices and specifications. Fully coded.

The Crypto Works Co., Ltd., 29, Clerkenwell Road, London.—Illustrated price lists of motors and dynamos, from four candle power up.

John Davis & Son, All Saints Works, Derby, England.—Catalogue entitled "Electric Mining," giving particulars of a variety of electrical appliances and electrically driven plant as used in mines.

Miller & Co., Ltd., London Road Foundry, Edinburgh, Scotland.—Well printed Catalogue of chilled iron wheels for tramways, chilled points and crossings and other chilled iron castings. Fully illustrated; also testimonials.

The Phosphor Bronze Co., Ltd., 87, Sumner St., Southwark, London.—*(a)* Collection of circulars giving strength, weights, tenacity, and other particulars of the alloys which are the specialty of the company; *(b)* Testimonials from users of Phosphor-Bronze and "Duro" metal for rolling mills, mining machinery, marine and stationary engines, etc.

Savage & Co., Love Lane, Eastcheap, London, E. C.—Illustrated price list of grocers' machinery, such as coffee roasters, tea bins, sugar cutters, scales, etc.

Redpath & Paris, Lea Cut Ironworks, Limehouse, London.—Illustrated catalogue of High Speed Noiseless engines, with full exposition of special advantages claimed.

The Improved Electric Glow Lamp Co., Ltd., 103, Queen Victoria St., London, E. C.—Catalogues of the "Electric Glow Lamp," with prices, fully illustrated, views of the firm's works and offices being included.

Oliver & Co., 61, Wilson St., Finsbury, London, E.—Loose sheet illustrating, pricing, and describing the "Oliver" patent arc lamps.

The Cotton Powder Co., Ltd., 32, Queen Victoria St., London, E. C.—Two pamphlets, first being entitled, "Twenty Years With Tonite, as a Safe High Explosive," and the second "Socket Signals for Signaling and Distress Purposes."

Crompton & Co., Ltd., Mansion House Buildings, London, E. C.—Series of illustrated catalogues and price lists of *(a)* Dynamos and motors for various industrial purposes; *(b)* Arc lamps, projectors and lamp hoisting gear, etc.; *(c)* Alternators, transformers and accessories; *(d)* Electrical cooking and heating apparatus; *(e)* Electrical measuring instruments; *(f)* Loose sheets pricing various electrical specialties. All these lists are coded and contain full descriptions of the machines, sizes, etc.

Siebe, Gorman & Co., Westminster Bridge Road, London, S. E.—Handsome catalogue of diving apparatus, diving bells, rock drills, salvage pumps and other submarine appliances, with prices and descriptive matter. Fully illustrated in half tone.

Geo. Smith & Co., Ltd., 13, Commercial Road, Pimlico, London.—Illustrated circulars of *(a)* The Parkinson Saw Guard; *(b)* Turner's Portable Fire Engine; *(c)* Portable Automatic Sack Hoist.

Evershed & Vignoles, Ltd., Woodfield Works, Harrow Road, London.—Illustrated price lists of *(a)* Evershed ammeters and voltmeters; *(b)* Electric gauges; *(c)* Dead-beat gauges; *(d)* Portable testing sets. In addition to prices and sizes, information as to working and special features is included.

M. Glover & Co., Leeds, England.—Folder illustrating and describing the "Ideal" saw guard, with testimonials.

The Reliance Lubricating Oil Co., 19, Water Lane, Great Tower St., London.—Price list of lubricants and patent oil- cabinets.

Holder & Brooke, Ltd., Sirius Works, West Gorton, Manchester, England.—Abridged catalogue of steam users' specialties, prominent among which are a balanced stop valve, a silent heater, and the "Sirius" pulsating pump.

The Langdon-Davies Electric Motor Co., Ltd., 101, Southwark St., London.—Illustrated catalogue of alternate current motors, with views of the firm's works.

Woodite Company, Mitcham Common, Surrey, England.—Pamphlet pricing "Woodite" packings and insulating materials, hose, washers, corks, etc.

S. E. Norris & Co., Shadwell, London, E. C.—*(a)* Handsomely illustrated price list of leather machine belting, pump and hydraulic leathers, etc.; *(b)* Price list of fire hose, leather fire buckets and gun metal fittings.

The Roller Bearings Co., Ltd., 1, Delahay St., Westminster, London.—Illustrated catalogue of roller bearings showing their application to tramways, shafting, mine fans, etc.

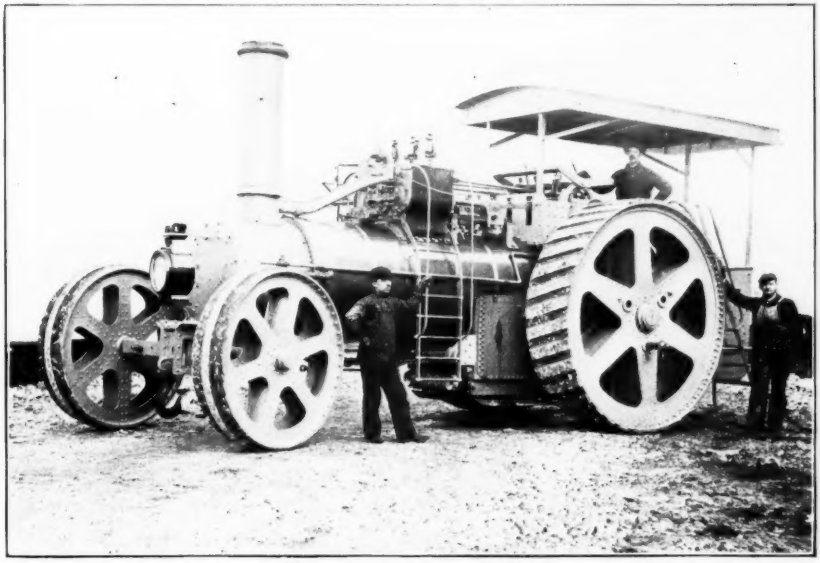
MECHANICAL PROGRESS

"Tools and the man I sing."—*T. Carlyle.*

NOTICE.—*The matter here published is not paid for, either directly or indirectly, and under no circumstances will a device be mentioned except by reason of our desire to make this department a record of what seems to be noteworthy examples of mechanical progress.*—THE EDITORS.

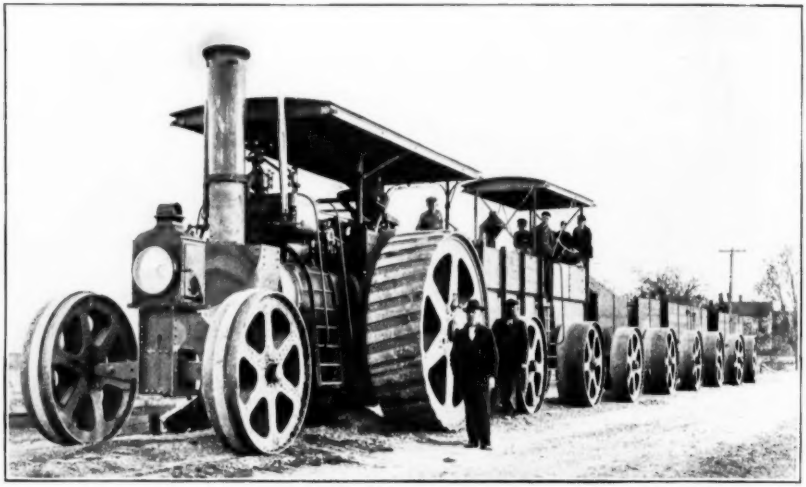
Overland Freighting Outfits.

THE use of traction engines for hauling merchandise is by no means new, but the improved engines shown in the accompanying illustrations, and built by the O. S. Kelly Co., of Springfield, Ohio, contain a number of excellent features, peculiar to them, and rendering them especially adapted to the general hauling of freight over such roads as may be found in nearly every civilized country.



An examination of the illustrations will show some of the improvements, notably the size and construction of the driving wheels, these being eight feet in diameter and 24 inches face, and built up of steel plates and angle pieces, riveted together around a center casting. The hollow box form of the spokes gives great strength together with lightness, while the use of three locking pins distributes the strain, and prevents undue wear on the pin hole.

The long bearing provides ample surface on the axle, while the diagonal strips on the rim of the wheel take all the wear of the road and are readily replaced when worn. The front wheels are five feet in diameter and 12 inches face, and have a central bearing band to facilitate steering, which is accomplished in the usual manner by hand wheel, worm and shaft, fitted with chains attached to the front axle.



The engine is made with three cylinders, with cranks at 120 degrees, the three-throw crank shaft being made of a single forging. The motion is sufficiently uniform to enable a fly wheel to be omitted, and the position of the cranks insures ample starting power at all times. The valves are operated by the well known Marshall gear instead of the link-motion, this form giving an excellent steam distribution, and enabling reversal to be made easily.

Steam is furnished by a locomotive boiler, with grate and heating surface proportioned to the work to be done, the strength being intended for a working pressure of 180 pounds per square inch.

The power developed by these engines is 120 horse power, which for a speed of three hundred and thirty feet per minute, gives a traction force of twelve thousand pounds at the wheel rim.

As shown in the illustration, the wagons are fitted with wheels of similar design to those on the engine, and with suitable wagons, and roads free from grades exceeding five per cent., it is stated that a load of thirty tons can be hauled thirty miles per day.

The duty naturally depends much upon the nature of the soil, and if the road be entirely free from loose sand, a greater load can be hauled than when the soil is unfavorable. It is stated that these engines have hauled over a natural dry soil, a total weight of one hundred and twelve tons.

Engines of this type are well adapted for steam plowing, in which case they are fitted with a five foot spool, arranged with an improved coiling gear which permits the coiling arm with its guide pulleys to swing around one side of the engine to the other without disconnecting any portion of the coiling gear, or disarranging the coiling of the rope.

Traction engines of this sort are most effective machines for developing the resources of a country prior to the advent of railways, and for use on large farms, estates, or plantations, they are becoming an important factor in the successful commercial exploitation of the land.

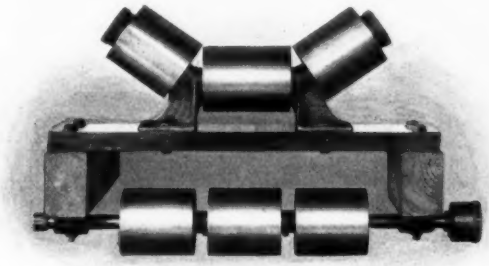
The Robins Belt Conveyor.

DURING the last eighteen months the perfected belt conveyors of the Robins Conveying Belt Co. have been used in so many fields to which belt conveying was formerly considered inapplicable, that a brief description of the system will doubtless be of interest.

A cross-section of the belt is shown in this cut, and its construction is the result of several years of experimenting with rubber belts for conveying purposes.

The perfected form of the Robins belt, as shown in the cut, combines the advantages of a central thickened cover with stiffened edges, which makes the belt bend more easily at the centre, and better preserves its troughed shape between the sets of idler pulleys. This stiffening is done by running two or three plies of duck a part of the way in from the edges.

In belt conveying the design of the idlers is as important as that of the belt. The cut shows the style of troughing and bottom idlers which is used by the Robins Conveying Belt Co. The troughing idlers are used to support the loaded belt. They consist of three cast-iron pulleys running on hollow steel shafts, which, in turn, are held in two cast-iron brackets. Lubrication is accomplished by forcing grease into the shafts with compression grease cups. In the shafts, holes are drilled through which the grease works under the hub of the pulley. Each grease cup holds a pound of grease, which is a sufficient supply for several months' constant running. The bottom idlers are used for supporting the returning or empty belt.



Steering idlers for upper and lower belts are also made. They perform no function ordinarily, but if the belt should run crooked from settling of the framework, or from any other cause, these idlers will prevent its becoming chafed or otherwise injured.

In all the idlers furnished by this company, hollow shafting for internal lubrication is used. The grease enters the bearing at the centre, and is constantly forced toward both ends, where it forms a collar, which keeps out dust and dirt. These idlers are, therefore, absolutely dust proof, and will work perfectly under the hardest conditions. In cases where the material is to be delivered otherwise than at the head end of the conveyor, a dumping device is used, which delivers at any fixed or movable point or points along the length of the belt, either automatically or not.

The angle at which the conveyor can elevate varies with the nature of the material to be carried. In all cases, quite a steep incline is attainable. Further information in regard to the system may be had from the Company, 147 Cedar street, New York.

Hunt Electric Hoisting Engine.

The engraving herewith illustrates one of the many sizes of the Hunt electric hoisting engine, which is designed from start to finish to be an electric hoisting engine, and is not a modified steam hoist with a motor attached. These machines are built suitable for high, moderate, and low hoisting speeds, and are properly proportioned for any load and speed desired.

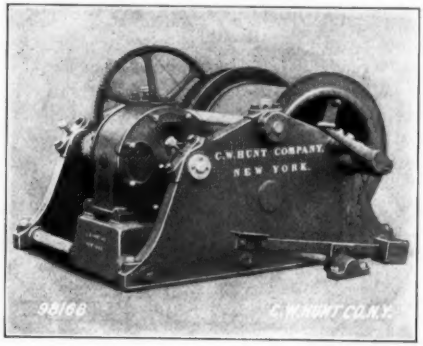
The bearings are supported by and are solid with the heavy side frame. Each bearing is bushed with a replaceable phosphor-bronze bushing, which can be readily replaced, as they are all made on the interchangeable system.

At the one setting, the side frames are faced and bored for the bearings and the distance bars, insuring absolute alignment The machine throughout is built to gigs and templets, and in no way is the work dependent upon the workmen's measurements.

As seen by the illustration, the armature shaft runs in bearings on the main frame in

such a manner that the pinion is not overhung, but is supported by the bearings, making a very stiff and smooth running machine.

In the construction, the armature is located by its shaft in the bearings, after which the fields are adjusted accurately to



the armature and then fastened rigidly to the distance bars of the machine. For this reason, the machine when received, is ready to go to work and needs no setting up, in the ordinary sense of the word.

The hoist shown, is operated by a friction clutch, which is so constructed that there is no strain tending to spread the frames. In other words, the device is self-contained.

A differential brake is used, assisting the engineer in its application and requiring very little physical force in its operation to hold and lower the load.

The oiling devices are exceptionally good, having been very thoroughly worked out. Each bearing has an oil reservoir of its own. The machine is entirely self-contained and is shipped in one piece. Manufactured by the C. W. Hunt Co., Cedar st., West New Brighton, Staten Island, N. Y., who will send illustrated catalogue on application.

A New Pipe Threading Machine.

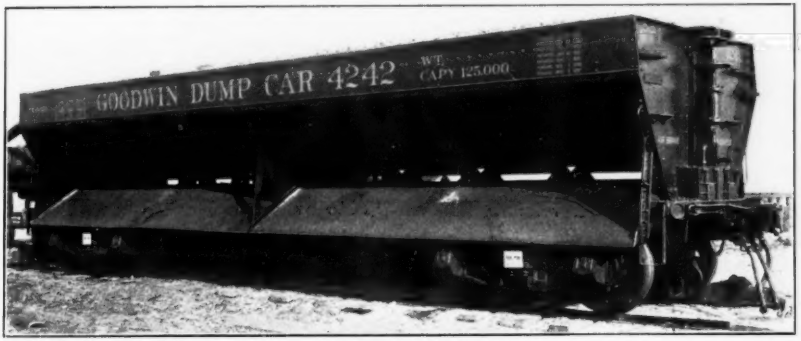
A NEW machine, which has just been placed on the market by the Armstrong Mfg. Co., of Bridgeport, Conn., is shown in the accompanying illustration. It is built on the same general plan of some smaller machines manufactured by the same company, but it has some important modifications. The new machine will thread pipe from one to four inches in diameter. It uses the regular Armstrong stock dies, which are put into the machine and adjusted in the same manner as the hand stocks. The dies can be opened after cutting the thread, and when the pipe is removed can be locked back to the standard size without resetting. This is accomplished by an automatic locking device, which is operated by simply pulling a lever. This lever is an improvement over the old form of machine, and is shown at the left of the illustration. The dies, however, can be adjusted to the variations of fittings, the same as in the stock. All the gears and moving parts of the machine run in oil, being enclosed in a chamber which covers them from chips and dust. The die head has no teeth on the part where it fits into the shell and forms a bearing, in this way preserving its bearing surfaces and making it impossible to get loose. In addition to this bearing being preserved by not revolving on top of the gear teeth, there is an inner journal of large diameter, thereby still increasing its wearing surface, and preventing the die head from becoming loose. A powerful self-centering vise, which exerts its power on the center of the jaw and not on the side, is used with this machine, and will

hold the pipe, being threaded, with a light pressure of the lever. The construction of the machine admits of its being fastened to a bench or placed on an iron stand which is furnished when desired. The machine here shown is designated as No. 00 and has a cutting off attachment for cutting pipes the same as the Armstrong Company's larger machines. The total weight of the new machine, without the stand, is 370 lbs.

The Goodwin Steel Dump Car.

THE Goodwin gravity dumping car, constructed of steel and operated by compressed air, has been designed to meet the growing demand for a more economical handling of all dumpable freights, and they appear to meet successfully many requirements heretofore wanting, especially in the class of dumping car known as the hopper gondola.

The advantages claimed in the special construction over the ordinary steel hopper



cars used for similar purposes are numerous; chief among the points of merit claimed are the greater resistance to every damaging force, especially crushing, sagging, or bulging strains. This strength is due principally to the special steel two-sill construction combined with the plate-steel side girder, which gives a cantilever support for the centre body of the car instead of the usual sagging strain, and, further, owing to the free overlap joint construction in the cargo box of the car, there is allowed free motion for contraction and expansion, giving greater ability than the ordinary riveted-steel construction to withstand the bulging, sagging, and warping strains caused by carrying either hot or freezing material such as most furnace managers have to deal with, and as the cargo box is clear above the main sills, any degree of heat or cold in the cargo does not in the least affect the main frame work of the car.

Further claims are that these cars require fewer men to handle the trains; they take less time to load and unload than the hopper car; and no shifting of cars is required on each trip, as is rendered necessary when plow and cable-drum are used in the unloading of flat cars; further, all material is placed where it is desired, either in the centre or on the sides of the track, or on both centre and sides, without the use of the plow on cars or on tracks, as is necessary with the usual ballast cars.

These cars are built with a capacity in bulk varying from 31 cubic yards to 68 cubic yards, and in weight capacity from 80,000 lbs. to 125,000 lbs., as required, and with either open crate or box top. They are equipped with special buffer and draft rigging and special trucks, both hand and air brake, and special spring side bearings, and ball and socket centre plates, enabling the heavy loads to ride easily over rough tracks at high speed with safety and with much saving of wear and tear on tracks and on the cars, over ordinary construction.

Other novel and interesting claims for these gravity dumping cars are that they discharge any material from loose gravel or sand to 500-pound rock, coal, limestone, coke, pig-iron, rail-ends, railroad-ties; grain, loose or in sacks; or any material that will escape through an opening 4 feet by 16 feet, and the load can be discharged by hand or by air from the air-brake system. The cars can be dumped separately or all at the same time by one man. Most materials will clear the car in less than a minute.

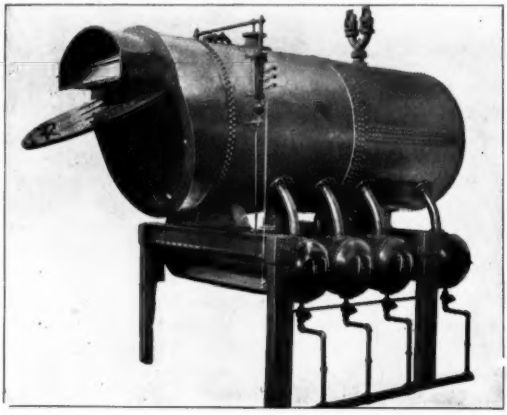
These cars are especially adapted for general coal and ore service and for ballasting, filling and track raising. The fact that they discharge their load all on one side, or in the centre, or part on each side, at

one time or separately, with gravity alone, without the use of plow on car or tracks and without the necessity of a trestle makes them especially desirable for handling all dumpable freight.

The amount of the discharge is regulated by the operator or by the speed of the train and the cars can be dumped standing or on the run.

Another special feature of construction which commends these cars particularly to the handlers of freezable materials, such as coal, ore, dirt, etc., is that the support of the load when the car is in carrying position, becomes the releasing valve when the load is discharged. This construction makes it possible for the car to discharge any load however firmly frozen, without difficulty.

Manufactured by the Goodwin Car Co., 96 Fifth avenue, New York, who will furnish catalogue and further information on request.



The Sederholm Boiler.

THE Sederholm Boiler has been designed to meet the growing demand for a high class steam generator, capable of working up to the highest pressures used in these days, while still retaining the well known advantages of the standard horizontal tubular boiler.

This boiler consists mainly of a tubular boiler of large diameter, connected to a series of cylindrical drums placed beneath. The object of this construction is to provide a roof, constructed of thin material, over the whole furnace, and to shield the thick shell of the large boiler from the action of the flame. The main shell is built up of several courses, and is so arranged that the fire will sweep through its tubes after having passed beneath the furnace drums. The tubes are arranged in two nests, with a wide space for circulation between them and they are placed so far away from the shell that all danger from leakage because of stiffness is avoided. The furnace drums are of comparatively small diameter, and are placed across the furnace, close together, so as to form a continuous roof over the fire, except that between the last two drums enough space is left for a bridge wall and arch. The furnace is made with an unusually high fire-box, no part of the furnace being nearer than three feet to the grate bars.

There are many other distinctive and unique features about the Sederholm boiler that are worthy of investigation, and the makers, Fraser & Chalmers, of Chicago, will be glad to send a special catalogue upon request.

INDUSTRIAL NOTES.

An important feature of the equipment of the Hoosac Tunnel Elevator, recently completed at Charlestown, Mass., for the Fitchburg R. R. Co., is the rubber belting which is used as carriers for the grain in the various galleries, and to which the buckets are attached for lifting the grain to the large storage bins. The contractor for the elevator, Mr. James L. Record, of Minneapolis, Minn., awarded the order for the belting to the Boston Belting Co., of Boston, Mass. It comprised about 7,500 feet of 36" 4-ply, 1,600 feet 38" 4-ply, and 4,800 feet of 22" 6-ply, besides a quantity of narrower belts. The total weight of all the belts was upwards of thirty-five tons. The longest 36" 4-ply belt measured 1,500 feet, and several others of the same width were more than 1,000 feet long each. Each of the 36" belts carries about 8,000 bushels of grain an hour. The belting in the original Hoosac Tunnel Elevator—built in 1881-82, and which was destroyed by fire in February, 1898—was supplied by the Boston Belting Co., and the excellent satisfaction which it had always given was a strong recommendation for the Company, and carried considerable weight in its favor in connection with the placing of the contract for belting in the new elevator just finished. Some of the original belts made in 1882, which were not destroyed by fire, are in first-class condition to-day and are doing good service in the present elevator.

The Snow Steam Pump Works, Buffalo, N. Y., have just closed a contract with the water commissioners of Dunkirk, N. Y., for a four million gallon pumping engine of the crank and fly-wheel type, and another with the water commissioners of Olean, N. Y., for a vertical-acting Corliss pumping engine, 1899 design.

It is announced that the Thomson-Houston Electric Co., owned and controlled by the General Electric Co., endeavored to enjoin the Bullock Electric Co., in the United States Circuit Court, southern district of New York, from using a magnetic blow-out with controllers, as they claimed the Bullock Electric Co. infringed two Thomson-Houston patents. Judge E. H. Lacombe, on March 6, after hearing the arguments in the case, refused to grant this injunction.

The American Impulse Wheel Company of New York report some very large electric transmission work in hand, and most valuable results from all their installations. The company is getting a large home and export trade.

The National Association of Manufacturers, of Philadelphia, have just published a descriptive and classified directory of its membership, embracing manufacturers who are engaged in export trade, or who make goods suitable for export.

We omitted to mention in our recent mention of "File Philosophy," a book published by the Nicholson File Co., that it would be supplied by the company gratis to anyone, upon request, from the main office at Providence, R. I. The book is being circulated widely, and is received with the utmost favor by all interested in files and their uses; it is of very practical value, and is highly appreciated by all who receive it.

The Roe-Stephens Manufacturing Co., of Detroit, Mich., have, within a year, shipped several duplicate orders of heavy gate valves to Honolulu, Hawaii. These are all due to the superb work done by the Scott valves, put in some time ago by the Roe-Stephens Co. on an important municipal job in that city. Of late the manufacturers have been taxed to get out their orders.

The Goodwin Car Company have at present under construction a number of their 80,000 pounds capacity steel, gravity, centre and side dumping cars, equipped with hand and air dumping apparatus. These cars are leased to several of the large railroads, and their principal use is for coal, ore, and broken stone.

F. W. Sahnon, of Burlington, Iowa, claims that split fly-wheels for small steam engines should have the point at or near the ends of the arms, instead of midway between them. His contention is that the present construction is defective on account of the bending strains set up in the rim by centrifugal force.

The Carnegie Steel Co. have abandoned their project of building steel cars, and, it is announced, have made a contract with the Pressed Steel Co. to stay out of that field for five years, the Pressed Steel Co, on the other hand, to purchase from the Carnegie Steel Co., all axles, plates, etc., required in the construction of their cars, amounting to 900 to 1,000 tons a day.

Edward P. Allis Co. have lately received, through their Pittsburg representative, contracts from the Carnegie Steel Co. and the Schoenberger Steel Co. for blowing engines.

Playford stokers will be installed in the 12,000 h.p. plants of the Ford Plate Glass Works, Toledo, Ohio.

The Wolverine Manufacturing Co., of Duluth, Minn., have recently purchased land for enlarging their plant, and contemplate employing 100 more hands as soon as the addition to their shops is ready.

Fred W. Wolf Co., Chicago, have prepared plans for a factory for the Oakland Sugar Mill Co., to consist of a group of buildings of different dimensions, the main one of which will be of fire-proof construction, 221 x 64 feet.

Westinghouse, Church, Kerr & Co. have furnished and have just started a 50-horse power gasoline engine in the Royal Victoria Hotel, Island of New Providence, in the Bahamas, which is direct connected to a dynamo for lighting the hotel. In the same Florida East Coast system of hotels, the Ormonde Hotel, in Ormonde, Fla., has just been furnished by the company with a 50 horse-power engine, direct connected to a generator for lighting purposes.

The Board of Water Commissioners of St. Paul, Minn., have awarded the Pittsburg Meter Co., East Pittsburg, Pa., the contract for supplying the city of St. Paul with water meters for the year 1899, this being the third successive year that these meters have been used in St. Paul.

By far the largest domestic order received by Westinghouse, Church, Kerr & Co., this year is the contract for the equipment of the Third Avenue Railroad Company's power house. This power house, the largest ever planned, and which is to be finished within two years, consists of 16 units (the engine and dynamo) of 3,000 kilowatts each. The power plant of the Metropolitan Traction is to have only eleven units. The total amount of the contract, exclusive of buildings, is about $5,000,000. The electrical machinery is to be furnished by the Westinghouse Electric & Manufacturing Co. The engines to drive the generators will have an economic rating of 4,000 horse-power. They are to be built by the Westinghouse Machine Company, and are to give the station the nominal rating of 64,000 horse-power, or a maximum capacity of about 100,000 horse-power.

The Lehigh Valley Railroad have just ordered from the Baldwin Locomotive Works two new engines, to be made from designs furnished by the Lehigh Valley company. If the machines are a success it is expected that some twenty-four of the same kind will be ordered for heavy freight service between Buffalo and Sayre. One of the engines will be a consolidation engine, with Vauclain cylinders, and the other will have simple cylinders of 21" diameter and 30" stroke. The tonnage of one of these engines on the territory named, where there are some long grades of 21 feet to the mile, will be 2,000 net tons, omitting weight of engine and tender. The following particulars of dimensions of the consolidation engine will be of interest: The two principal features of the new engine are the large boiler and hence large heating surface, and the diameter of the driving wheels, 62" over the tire; high pressure cylinder, 17" diameter; low pressure cylinder, 28" diameter; stroke, 30"; driving wheels, 62" over tire; rigid wheel base, 16 ft. 3 in.; total wheel base, 25 ft. 5 in.; height from top of rail to top of stack, 15 ft.; weight on driving wheels in working order, 155,000 lbs.; total weight of engine in working order, 175,000 lbs.; boiler pressure, 200 lbs. per square inch; 358 boiler tubes, 2" diameter, 15 ft. 1 in. long; piston rods, 4½" diameter, made of nickel steel, 3 in. core; driving journals, 8½ x 11 in.; all driving-wheel tires flanged; engine-truck wheels, 36 in., steel-tired; water capacity of tender, 4,500 gallons; tender-truck wheels, 36 in. diameter, steel-tired; tender-truck axles, journals, 4¼" x 8" M. C. B. standard; Westinghouse tender and train brake; American driver brake.

MECHANICAL PROGRESS

"Tools and the man I sing."—*T. Carlyle.*

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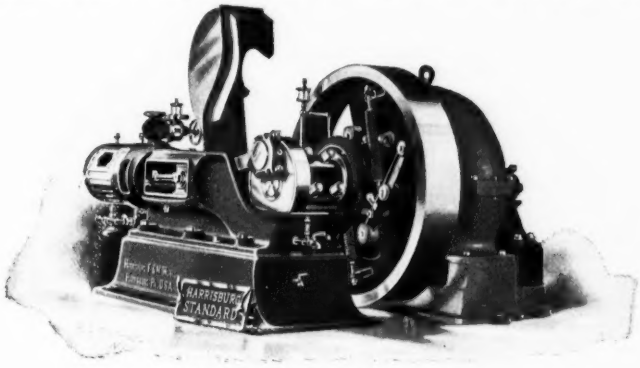
The Harrisburg Self-Oiling Engine.

THE illustration shows the Harrisburg simple single valve engine. A peculiar feature of these engines is that they are all constructed with side cranks, requiring only two main bearings, whether designed for direct-coupled or belted service, and thus many of the disturbing elements that attend the operation of three or four bearing engines, such as excessive friction and bad alignment, are removed, the friction loss in these machines being according to the manufacturers, less than two per cent.

The simple engine is compact, its high efficiency is due to a combination of new features. These features include an automatic oiling device, by which the crank disc, connecting rod and cross-head are enclosed, and the case provided with a hinged hood, which may be turned back, and a plate on the side, which may be easily removed for inspection and adjustment of reciprocating parts. This arrangement of the hood makes its removal unnecessary, as all adhering oil drains back into the engine frame. By the revolution of the disc the oil is splashed over the wearing parts, including the cross-head, and by means of a lateral internal trough across the inside of the cover, a large portion of the oil is led out through a pipe and directed in a stream upon the main bearing adjoining the crank disc. The lubrication of the crank pin is accomplished by means of an eccentric annular chamber, recessed in the face of the disc around the main shaft next to the main bearing, from which a diagonal hole is drilled through the disc, coming out about the middle of the surface of the crank pin, so that by centrifugal force a constant volume of oil is provided for its lubrication, completing the circulation from reservoir to cross-head, main bearing, crank pin, and finally draining to reservoir again.



HARRISBURG SELF-OILING ENGINE.

The governing mechanism is also a special feature of these engines, and is of the centrally-balanced, centrifugal-inertia typ

Roller bearings are provided in the governor bearings, and the principal mechanism consists of two balanced levers, which are connected to an eccentric sleeve which surrounds the shaft and is pivoted at one side, thus controlling the throw of the eccentric rod to a nicety.

The pillow blocks for the crank shaft have the cover fitted diagonally, and the shell is provided with an oil chamber with a recess for the oiling rings. The engine frame is extended, with stuffing box exposed in such a position as to provide for constant and easy access, and prevent the water of condensation from getting into the oil supply, should a leak occur.

Although the Harrisburg Standard engine was designed but a year ago, there are already in operation seventy-five of these machines, with orders for twenty-five more in the shops. The makers, the Harrisburg Foundry & Machine Works, Harrisburg, Pa., will send illustrated descriptive catalogues of this engine on application.

The Canda Cam.

This is an invention of singular merit, efficient, and simple of adjustment, and the advantages obtained by the use of this fastening are numerous. The device consists of an eccentric wedge chamber, such as can be formed by the continuous revolution of a boring tool, fitting into the bore of the ordinary stamp cam; this chamber occupies only a portion of the width of the eye of the cam. There is a circular wedge key within this chamber and a slot or recess in both the key and the cam, to enable the studs or projections on the cam shaft to engage the wedge key and hold it in position.

THE CANDA CAM.

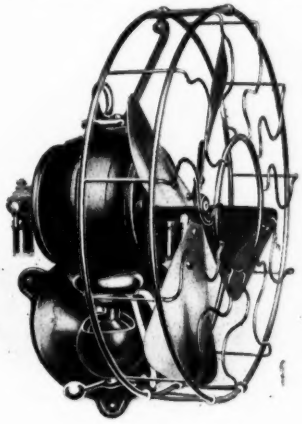
It will be seen that these cams, by reason of the position of the studs on the cam shaft, are interchangeable, that is to say, each of the series of cams will take any one of the angular positions as determined by these studs. This feature is indeed important, as, when breakages occur, the delays incident to the stopping of mills, cutting keyseats, removing cam from shaft, etc., are reduced to a minimum.

The fastening is also essentially selftightening under a working load, and can never work loose, and, therefore, mills are not forced to stop to key-up cams, as is often the case where the ordinary tapered key is used. Nor is dependence placed on the shearing stress, as with the ordinary key, for the circular eccentric wedge takes hold upon the shaft, and the studs are thereby relieved of the major portion of the shearing stress to which, otherwise, they would be subjected. It may be pointed out that the frictional adhesion between the shaft and the concentric face of the circular wedge is so great that the wedge may be said to be practically in compression. The cams may, however, be readily loosened by striking the arm a slight blow on the reverse side. The introduction of this fastening does not affect the strength of the cam, as the full width of the hub is retained; nor is the hub subjected to strains out of proportion to the work to be done, as often occurs where the ordinary driven key is used.

None of the apparent advantages noted above is more important than the feature of ready adjustability to the ordinary existing cam shaft. This fitting may be done by hand, if necessary, with a ratchet drill, after which the studs may be driven into place. It is not necessary to procure a shaft of any special type, nor are any special machines or tools required to bore the cam. All the machine-work may be done on an ordinary lathe or boring mill. This fastening may also be applied to gears, pulleys, etc., and, in fact, to all parts of machines that rotate under load in one direction. The cams are manufactured by the Chrome Steel Works, Brooklyn, N. Y.

Lundell Fan Motors.

It is but a short time since fan motors were looked upon as an ingenious toy rather than a useful device for promoting the



comfort of mankind, but now we have come to look upon them as a necessity, and many an uninhabitable, poorly ventilated

place has been changed into a very pleasant work room by a few, well-placed electric fans. At first little particular attention was given to compact, economical and artistic design, efficiency, etc., but now as much talent is brought to bear upon the construction and design of these small motors as upon the larger power motors. Much attention is given to simplifying the parts, as well as to efficiency and economy in operation, as these are important features from the viewpoints of the dealer and the central station supplying the current.

The illustrations on this page show two forms of the Lundell fan motor, manufactured by the Sprague Electric Co., New York—the 12-inch desk pattern, and the 12-inch bracket pattern. A notable departure in the fan motors now constructed by this company is the substitution of drop-forged field frames for the cast frames heretofore used. This is claimed to increase the efficiency of the motor, while decreasing the weight. All field pieces are forged in the same die, and are, therefore, perfectly interchangeable. A new fan guard is also used this year, the wire being of heavier gauge, and in consequence, more substantial.

The Sprague Company is just issuing a very handsome catalogue of Lundell fan motors, which they will send free upon request.

Ball Pulverizing Mill.

The small illustration herewith is of a ball pulverizing mill manufactured by Frazer & Chalmers, Chicago, and consists of a horizontal barrel built up of steel plate, with cast iron heads, having trunnions upon which the machine revolves, the barrel and heads being lined throughout with hard white-iron liners. Within the barrel are placed hard white-iron balls, the ore being pulverized by these balls as the barrel revolves. The material to be pulverized, which should previously be reduced to about four mesh, is charged into the barrel through one of the trunnions, and is discharged from the barrel through the trunnion at the opposite end. The fineness to which the material is reduced by the pulverizer is regulated by the speed with which it is charged into the barrel; the slower the charging the slower will be the discharge, and therefore the longer will the material remain under the action of the balls, and consequently the finer will be the product.

The pulverizer is furnished with heavy

bearings for the trunnions and with suitable driving mechanism to rotate the barrel. The standard size barrel is 6 ft. dia. x 7 ft. 4 in. long inside the liners.

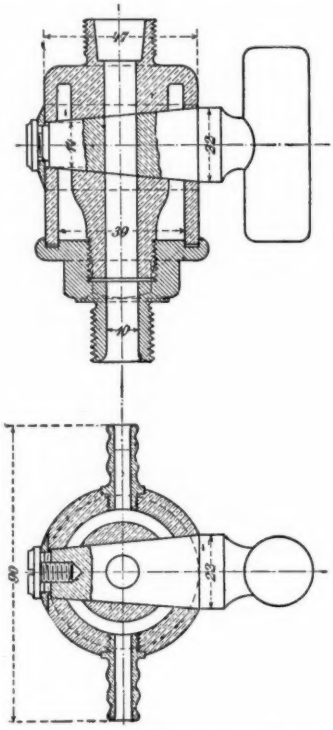
The shell of the barrel is built up of a single plate of boiler steel, having a longi-

tudinal joint with an outside butt strap, the shell plate coming flush on inside and the butt strap being riveted to same with rivets having countersunk heads on the inside of the barrel. In the shell is placed a man-hole with heavy cast-iron frame, suitable cover and crabs, this man-hole being used only for the purpose of relining the barrel, and not for charging or discharging. The shell is properly caulked all over and tested to insure water tightness.

Into each end of the shell is riveted a cast-iron head, strongly ribbed, and provided with a heavy trunnion cast in same piece. In order to minimize wear on the trunnions there is shrunk upon each of them a turned and bored shell of forged steel, forming the actual working journal. The trunnions are suitably cored out for feed and discharge. To the trunnions are fitted suitable feed and discharge rings to prevent material from flowing back when being charged in, and from reaching the trunnion bearing when being discharged. An illustrated leaflet describing this mill in detail will be sent free by the manufacturers.

An Improved Attachment for the Indicator.

In taking indicator cards from gas engines and similar internal combustion motors the high temperatures are liable to injure the indicator if a number of cards are taken continuously for any length of time. In order to avoid this difficulty, and to permit the indicator to be operated as long as may be necessary an ingenious form of stop-cock connection has been devised by Messrs. Dreyer, Rosenkranz & Droop, of Hannover, Germany, in which the barrel of the stop-cock is water-jacketed. As shown in the illustration there is a space around the barrel through which the plug passes, and by making connections with small pieces of rubber tubing to a water supply and a drain a continuous circulation of water may readily be maintained. The heat is thus entirely prevented from reaching the indicator and the entire instrument remains cool, even during prolonged communication with the cylinder. Such a de-



vice is hardly to be recommended for indicating steam engines, as it would be apt to cause condensation, but for use with internal combustion motors it may prove a very useful auxiliary.

MECHANICAL PROGRESS

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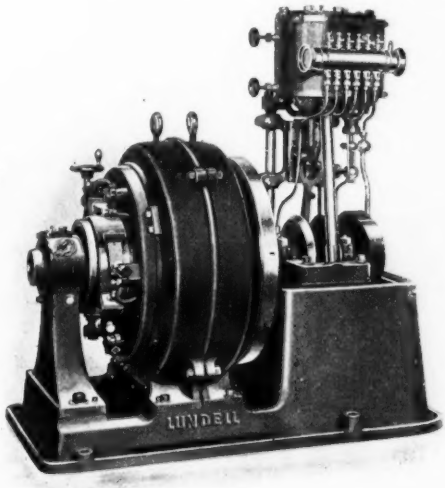
A Lundell Direct-Connected Generator.

THE illustration shows a Lundell generator driven by direct connection to a Forbes marine type engine. The size of the generator shown here is nominally of 8 K.W. capacity, having a speed of 500 R.P.M., and capable of operating an equipment of 160 sixteen C.P. lamps at full candle power. The set from which this photograph was made has been installed on the steam yacht "Postmaster General" now doing duty in New York harbor. When the plant was installed an exhaustive test was made which showed that the apparatus is capable of developing 10.8 K.W., supplying 216 lamps. As the primary qualities in a direct-connected set for marine work, especially by yachts and similar classes of vessels, are compactness, light weight, ability to stand overloads, and accessibility, it will be seen that these points are met when it is mentioned that the total weight of this set is 1,050 lbs., or about ⅛ pound per watt output. The amount of space taken is small, being 27″ wide by 6′ 2″ long, the height being 38″.



One particular feature of this set is excellent—the center of gravity is low, insuring a great degree of stability. The ability of the generator to carry an overload without sparking at the brushes is due to the series-wound armature and the use of a single field coil, which is a peculiar feature of Lundell generators. This single coil magnetizes all the different field poles to the same degree of intensity. The armature is

well ventilated. The commutator is large in diameter and breadth of face, which allows the commutator to run cool. The magnetic circuit is very short, requiring less copper to energize the field, and thus conduces to high efficiency.

The details of both generator and engine are carefully worked out; the engine runs smoothly and without vibration. The generator will meet the most exact specifications in regard to heating, sparking limits, and efficiency.

The Sprague Electric Co., New York, are supplying these direct connected types in the following sizes, 8 K.W., 16 K.W. and 32 K.W., generating current for 160, 320, 360 and 640 lamps respectively. The company also state that they have found it necessary to operate their factory on an average of fifteen hours a day in order to meet the increased demand for their motors and generators.

An Electric Propeller Ventilating Fan.

SINCE the B. F. Sturtevant Co., of Boston, Mass., has entered extensively upon the manufacture of electric motors and generating sets, it has been carefully studying the problem of the manufacture of a compact, efficient and convenient type of electric ventilating fan. Exhaustive tests were made with different types of fan wheels. The result is rendered clear by the accompanying engraving, showing one of their electric ventilating fans which have just been put upon the market.

The fan wheel has eight blades, rigidly attached to a spider at the center, and held in place by a hoop at the periphery at an angle of, approximately, 30 deg. The angle is increased in such a manner that as the center is approached, the theoretical velocity of the air remains practically constant. In other words the delivery edge is helical, and the air is picked up on the inlet edge of the blades at low velocity. When well under the influence of the blades it is accelerated to its maximum velocity with the least amount of slip. The result is an extremely efficient wheel.

The motor likewise has been the result of very careful study in the attempt to provide a light machine, entirely enclosed, and at the same time to avoid the excessive temperature which is incident to the operation of most enclosed motors. The result is a machine capable of continuous operation for 10 hours, with a maximum temperature rise not exceeding 30 deg. F. A practical efficiency of over 80 per cent. is obtained even with the small-sized motors, and an excess load of 75 per cent. above the rated capacity may be carried without sparking and without change of

brushes. This feature, combined with the small temperature rise, allows of carrying temporary overloads with safety.

The bearings are self-oiling and self-aligning, and are fitted with phosphor-bronze sleeves which are removable from the outer ends of the boxes.

The wheel is partially enclosed within a conoidal inlet ring, which decreases the frictional resistance to the entering air, and furnishes, at the same time, a rigid support for the motor to which it is attached by the tripod hanger.

These fans are built in sizes from 18 inches to 120 inches, with motors designed for either medium or maximum speed, and to run at any ordinary direct-current voltage. A speed controller is always provided, by means of which the fan can be efficiently operated at different speeds.

The Jeffrey Conveyor.

THE Jeffrey Wire Rope Conveyor, of which the accompanying illustration is one type, is rapidly coming to the front as one of the most convenient, as well as economical, systems for the conveying of material

of various kinds. In its construction the best steel rope is used, to which are attached steel or iron clamps of a design to suit the special requirements.

In the illustration it is used as a coal conveyor, the flights being spaced 24" apart, while the whole operates over specially-arranged gap wheels. These conveyors are made endless by a special coupling furnished with each conveyor. This type of conveyor is one that can be driven from the receiving end, no matter whether the length is 100 or 1,000 feet. It works perfectly in the handling of coal, fine ores, earth, as well as in the conveying of refuse in lumber and wood-working establishments.

Special printed matter upon this subject can be had by addressing the Jeffrey Manufacturing Company, at its works and main office, Columbus, Ohio, or at any of its branches.

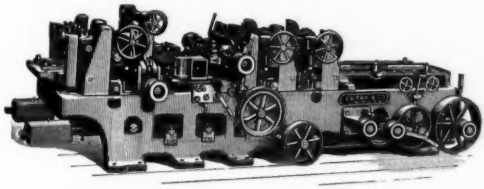
A New Floorer.

THE accompanying illustration is of a flooring machine made in two sizes, to plane four sides 10" and 15" wide and 6" thick. The framing is massive, strongly braced inside to resist all strains and vibrations and has heavy girts, so placed as to come under the working parts of the machine where there is the greatest resistance. All surfaces are accurately planed and securely jointed, and it is the latest product of the works of J. A. Fay & Co., 271 to 291 W. Front street, Cincinnati, Ohio, and is known as their No. 15, new six-roll double-cylinder "Lightning" flooring machine.

The cylinders are two in number, made from solid steel forgings, have four faces slotted to receive two or four knives, and chip-breaking lips for working cross-grained lumber.

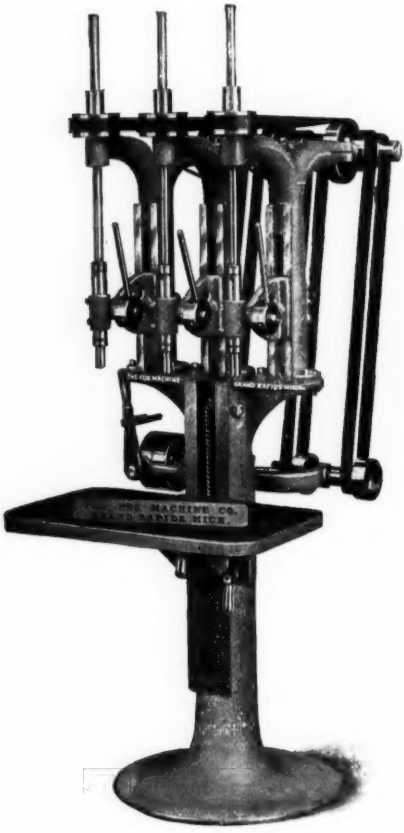
The matching works are heavy. The arbors are of steel 1¾" in diameter where the cutter-heads are applied, and revolve in long, self-lubricating bearings, both of which are adjustable vertically and horizontally, and are rigidly locked in any desired position by a lever conveniently located outside the frame. The top plate of each matcher hanger is detached from the main casting for convenience and economy. Will match stock as narrow as 1½".

The feed works consist of six large feed



rolls, 8" in diameter, driven by a train of gearing, each gear on a shaft extending through the machine and running in babbited bearings. The expansion gears on

feed rolls are inside the frame, and run in bearings. The screws for raising the rolls do not revolve, the rolls being mounted in sleeve housings that travel on the screws. This makes the roll adjustment very easy, as the pressure weights do not have to be lifted. It has three speeds of feed; viz., 30′, 45′, and 60′ per minute. The feed is under



instant and positive control of the operator by means of a lever engaging a ring friction. The pressure bar before the upper cylinder is adjustable to and from the cut, and has a chilled toe, reducing wear to a minimum. The bar after the cut is adjustable for difference in thickness of material. The bars before and after the lower cylinder are adjustable to and from the cut, and are vertically adjustable for varying depths of cut. The bar over the lower cylinder is adjustable on heavy stands, and securely locked in position. A continuous pressure bar extends over the matching works with independent adjustment, and can be quickly thrown out of the way to give access to the heads.

The builders of this new machine also make a full line of high-grade machines for manufacturing articles of every description, out of wood, and they can furnish single machines or complete outfits for any kind of plant with their make of machinery, and they will be pleased to give full information on improved wood-working machinery.

Fox Three-Spindle Drill.

THE three-spindle high-speed drill shown herewith was first manufactured by the Fox Machine Co., Grand Rapids, Mich., for their own use, as they could not find anything on the market which met their ideas of a high-speed drill. The company is now manufacturing the drill for the market, so that others may secure through it the benefit of the experience of the makers in designing a drill for their own use, rather than to sell.

Attention may be drawn to the beauty of design, with proper distribution of metal. All shafts run in removable bushings which may be renewed at small expense, when necessary. There are three changes of speed for each spindle independently, while the spindles are counterbalanced by a quick-acting spring. Eccentric clamping levers hold the table firmly and give quick adjustment. The tables are larger than the common—and are counterbalanced in column on multiple-spindle drills, while being adjustable to length of column to take in large and irregular jigs. There is an adjustable collar on top of each spindle (not shown in the illustration) to gauge depth of holes. The manufacturers will furnish illustrated catalogue and further particulars on request.

NEW CATALOGUES AND TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine when you write.

Sullivan Machinery Company, Chicago, Ill., U. S. A.—Catalogue No. 29, devoted principally to the diamond core drill, with practical descriptions of the machines and complete instructions for setting up and operating them. Lists of prospecting outfits are given, and a number of testimonials from various parts of the world.

John A. Mead & Co., Rutland, Vermont, U. S. A.—Fully illustrated catalogue of machinery for handling coal, ore, phosphate, and similar material, including automatic and cable railways, conveyors, steam shovels, reloaders, and coal elevators. Many illustrations of executed plants are given from photographs.

The Westinghouse Machine Company, Pittsburg, Pa., U. S. A.—Beautifully illustrated catalogue of the Westinghouse "Junior" engine, giving specifications and detailed description of all parts, together with tables of dimensions, capacities, and steam consumption under test.

The Taunton Locomotive Manufacturing Company, Taunton, Mass., U. S. A.—Catalogue "E," illustrating and describing various forms of the Wainwright appliances, including feed-water heaters, surface condensers, and expansion joints. Corrugated copper tubes are used in all three devices, thus providing for expansion and contraction and permitting rigid and tight joints to be made. Detailed drawings and specifications are given for the various sizes, with much useful information relating to the heating of water and the condensing of steam.

Barr Pumping Engine Company, Philadelphia, Pa,. U. S A.—Supplementary catalogue of Barr pumps, giving illustrations and tables of sizes and capacities of standard duplex boiler feed pumps, deep-well pumps, fire pumps, and pumps for general service, including belt and electrically-driven pumps. This is supplementary to the larger general catalogue, which together with copies of duty tests may also be had on application.

The Pelton Water Wheel Co., San Francisco, California, U. S. A.—First Spanish edition of the general catalogue of Pelton water wheels, containing, besides a full description of the Pelton wheel, numerous valuable tables relating to the flow of water and the capacity of pipes, the dimensions and other data being given in the metric system for use in Spanish speaking countries.

E. W. Bliss Co., Brooklyn, N. Y., U. S. A.—Catalogue of presses, dies, shears and special machinery for the rapid and economical production of tin and sheet-iron ware in all varieties. Many different forms and sizes are illustrated, with capacities and character of service indicated.

Ferracute Machine Co,. Bridgeton, N. J., U. S. A.—Catalogue No. 12, illustrating and describing the full line of presses and dies for the shearing, cutting, punching, bending, forming, embossing, coining, drawing, deepening, broaching, etc., of bar and sheet metals. Tables of dimensions, capacities, and prices are given.

The C & C Electric Company, New York—Bulletin No. 129, illustrating and describing bipolar dynamos and motors, and ventilating combinations. The straight and the curved field types are shown, together with tabulated information enabling plans for installation to be readily made.

Westinghouse Electric and Manufacturing Co., Pittsburg, Pa., U. S. A.—Handsomely illustrated pamphlet catalogues *(a)* of generators and rotary converters for electrolytic work; *(b)* of single reduction railway motors; *(c)* of belt-driven railway generators; and *(d)* of Tesla polyphase induction motors. These are perforated in the style of all the Westinghouse pamphlet catalogues, to be made up in sets as may be required.

Climax Road Machine Co., Marathon, N. Y., U. S. A.—Illustrated catalogue of road-making machinery, including stone crushers and elevators, distributing wagons, horse and steam rollers, plows, scrapers, and miscellaneous tools. Illustrations of municipal crushing plants are given.

Wm. Baragwanath and Son, Chicago, Ill., U. S. A.—Catalogue of steam-jacketted feed-water heaters, purifiers, and condensers, illustrating various types and sizes, together with a list of one hundred customers.

B. F. Sturtevant Co., Boston, Mass., U. S. A.—Bulletin "M," illustrating the Sturtevant electric propeller fans and enclosed electric motors for ventilating buildings of all kinds, including smoking and dining rooms, restaurants, kitchens, bakeries, laundries, engine and boiler rooms, etc.

The Gardner Motor Co., New Orleans, La., U. S. A.—Catalogue of the Gardner gas and gasoline motor, especially adapted to marine work, giving many illustrations of applications to launches and other boats, using both screw propellers and stern wheels.

The Standard Steel Works, Philadelphia, Pa., U. S. A.—Handsomely printed and bound catalogue, devoted to a description of the method of manufacture of steel tires, with numerous views of the works of the company at Burnham, Pa., and a number of valuable plates showing the accepted methods of fastening steel tires to wheels, full size dimensioned sections being given. The standard requirements, both chemical and physical, are given for American, English, Russian, Japanese, and Finnish practice.

W. A. Jones Foundry and Machine Co., Chicago, Ill., U. S. A.—Catalogue of machinery for transmitting power, including iron and wooden pulleys, shafting, hangers, couplings, clutches, rope sheaves and collars. Conveyors and elevator buckets are also listed, and transmission chain and sprocket wheels.

Illinois Steel Company, Chicago, Ill., U. S. A.—Catalogue of steel Portland cement, giving data as to tests of Portland cement made from furnace slag, together with numerous illustrations of important structures in which this cement has been used.

MECHANICAL PROGRESS

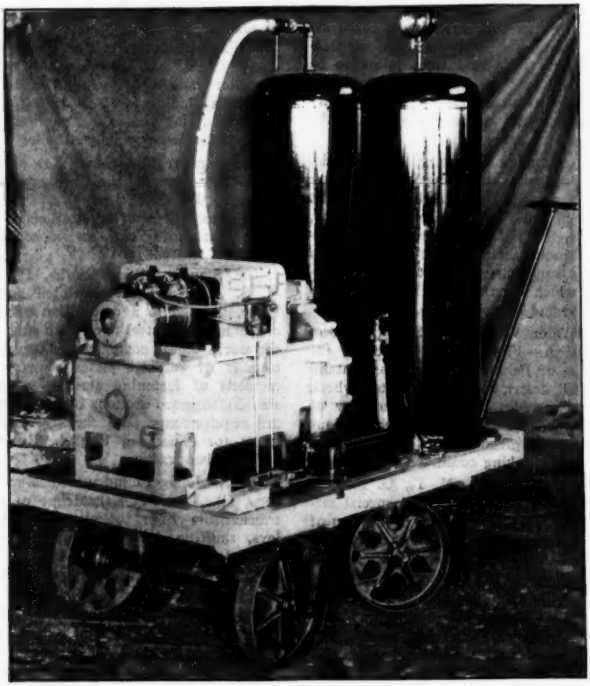
"Tools and the man I sing."—*T. Carlyle.*

NOTICE.—*The matter here published is not paid for, either directly or indirectly, and under no circumstances will a device be mentioned except by reason of our desire to make this department a record of what seem to be noteworthy examples of mechanical progress.*—THE EDITORS.

A Portable Air Compressing Apparatus.

THE Christensen Engineering Company, of Milwaukee, Wis., has recently put on the market a neat and compact compressing apparatus to be used wherever electric current is available, for such purposes as cleaning car cushions and operating pneumatic tools, either for chipping, caulking, or drilling. The apparatus illustrated weighs about 1,400 pounds, and is strictly portable and self-contained. The air-compressor has a capacity of 50 cubic feet of free air per minute and is of the same style and pattern as this company is putting on the market for air brake purposes, but they are prepared to furnish this kind of portable apparatus in sizes ranging from 10 cubic feet to 300 cubic feet free air per minute.

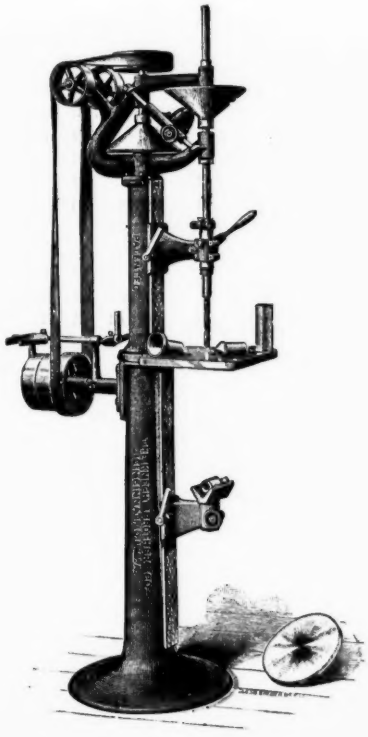
The air-compressor is self-contained and all the working parts run in an oil bath, the motor being arranged on top of the compressor, and connected to the compressor crank-shaft by means of a gear and



pinion. The compressor delivers air into the reservoirs, from which the compressed air is conveyed by hose to the working point. The compressor is controlled by an automatic governor which is operated by the pressure of air accumulated in the reservoirs in such a way that the motor stops whenever the pressure is at a maximum, and starts when it is at a minimum, with any desired variation between the two extremes.

The compressor is not provided with a water jacket, as experience has shown that in this form of construction the compressor will run half the time without any undue heat. This makes the apparatus much more practical than if it were necessary to have cooling water around the cylinders and the back heads, thereby introducing extra complications.

The box which encloses the motor compressor, together with the electric apparatus in connection with it, is water-tight and is so arranged that access is readily had to all the various parts of the apparatus by simply opening the doors arranged in the box for that purpose.



A Friction Sensitive Drill.

THE Knecht Brothers Co., Cincinnati, Ohio, are placing on the market the friction sensitive drill which is illustrated herewith. The driving mechanism consists of two cones and a friction roller, the power being transmitted from the lower cone to the friction roller, which in turn transfers power to the upper or spindle cone. The speed of the drill spindle is increased or diminished without stopping the machine or belts, by simply sliding the frame upon which the friction roller is mounted. The driving power is changed by increasing or decreasing the tension. Extending through both bearings of the housing is a sleeve or bushing to which the driving cone is fastened, relieving the spindle of lateral pressure, which enables the machine, when properly oiled, to run any length of time without heating. The spindle sleeve or bushing has ball thrust bearings. On the shaft guiding the friction roller or transmitter are graduations showing the positions in which it should be placed to obtain proper speeds for any sized drill from the smallest to the largest.

There are also graduations on the sleeve passing through the spindle head, indicating the depth to be drilled. In addition there is a stop collar on the sleeve, which can be adjusted and set so as to drill any number of holes a fixed depth without referring again to the graduation on the sleeve.

The different manipulations, adjustments, and all operations on the drill press are easily made without the necessity of the operator's leaving his position in front of the machine.

Portland Cement for Marine Work.

SEVERAL months ago a review was made in THE ENGINEERING MAGAZINE of some Austrian experiments upon the behavior of cements when exposed to the action of sea water, and it was shown that in some instances cements otherwise of high re-

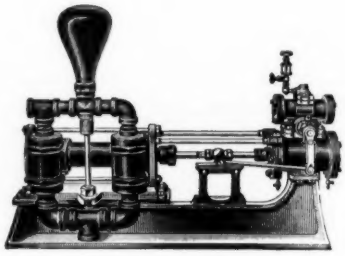
sisting power became rapidly disintegrated when exposed to the influence of the sea. The remedy was shown to lie in the prevention of the presence of free lime, which could be accomplished by the admixture of puzzolana or similar material.

It is now announced that Mr. H. J. Livingston, of Baltimore, Md., proposes to render Portland cement capable of resisting the action of sea water by adding to it a mixture of carbon, hydrocarbon and slaked lime. While a very large proportion of lime hydrate can be added, even up to 125 per cent., without diminishing its hydraulicity, it is found that from fifteen to twenty-five per cent. giyes the best results. It is claimed that under Mr. Livingston's treatment a slow setting cement, free from cracking, is produced, and that it is very plastic and adhesive, and especially well adapted for use in marine structures owing to its capacity for resisting the disintegrating action of sea water.

A Hard-Rubber Acid Pump.

THE illustration of a pump shown herewith gives a good idea of the general appearance of an acid pump made of hard-rubber by the American Hard-Rubber Co., of New York. The pump is especially designed for conveying acids, chemicals, dyes, etc., or any volatile liquid, being constructed in such a manner that all parts which come in contact with the liquid are hard-rubber which, as is well known, is exempt from the action of acids. These parts are held by and mounted on iron, which takes the strains incident to the work performed. in a word, the rubber serves as a lining and complete protection against corrosion or other action on the metal.

The pumps of this type are made in a variety of patterns. That shown in the engraving is provided with a steam cylinder; but they are made also to be operated by



pulleys, by gearing, or by an electric motor. In each of the types the pump is mounted on a substantial iron bed-plate and is complete in itself, ready to be placed on timbers or other foundation.

These pumps were designed in the first place for chemical works; but, as will readily be seen, they find many applications in mines and mills. In copper and other mines where acid waters have to be pumped which corrode iron and steel in a short time, and in mills where acid and other solutions are handled, their utility is apparent. The manufacturers design special pumps for unusual and exacting service, and will be glad to send full descriptive matter on request.

NEW CATALOGUES AND TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine when you write.

The Harrisburg Foundry and Machine Works, Harrisburg, Pa., U. S. A.—Handsome catalogue describing the system of steam engines made by the concern, as well as other products, including boilers, furnaces and road-rollers. A copy of the *edition de luxe* of the same catalogue has also been received, handsomely bound and ornamented, for special distribution.

The Chisholm & Moore Manufacturing Co., Cleveland, Ohio, U. S. A.—Catalogue of chain hoists operated by pneumatic, electric, and hand power, also of pneumatic cranes, and of trolleys for use with chain hoists.

The Winslow Bros. Co., Chicago, Ill., U. S. A.—Portfolio catalogue containing reproductions of bronze decorative work, including gates, mausoleum doors, panels, tablets, etc., the whole forming a remarkably handsome collection both as regards the original subjects and the manner of their presentation.

Baldwin Locomotive Works, Philadelphia, Pa., U. S. A.—Record of recent construction, No. 13, containing numerous valuable diagrams for the determination of piston speeds, tractive power, speed resistance, hauling capacity, etc., together with the formulas from which the diagrams have been constructed and instructions as to their use. The whole forms a valuable collection of information having the practical endorsement of the firm by which it is issued.

Merchant & Co., Philadelphia, Pa., U. S. A.—Small pamphlet describing the improved method of dipping tin plate adopted by the firm for the purpose of insuring a uniform thickness of tin coating over the entire surface.

Fraser & Chalmers, Chicago, Ill., U. S. A.—Catalogue No. 3, Fourth Edition, devoted to methods and machinery for roasting, smelting, and refining, for gold, silver, lead, and copper. Numerous illustrations and plans of standard appliances are given, together with useful information as to methods of work.

The Snider-Hughes Co., Cleveland, Ohio, U. S. A.—General catalogue No. 11, of steam pumps, high-duty pumping engines, hydraulic machinery, air compressors, and air-lift plants; with illustrations and specifications of the different machines, and a number of useful tables of the properties of water and steam.

The McConway & Torley Co., Pittsburgh, Pa., U. S. A.—Handsomely bound catalogue of the Janney coupler, for passenger cars, freight cars, and locomotives. Plates of all the various parts are given, together with lists of pieces by number, and a very complete index, rendering the catalogue most valuable for reference.

The Ball Bearing Co., Boston, Mass., U. S. A.—Catalogue of ball and roller bearings for all kinds of machine construction, shafting, and vehicles, with price lists and telegraph codes.

The Barber Asphalt Paving Co., New York.—Descriptive catalogue of genuine Trinidad lake asphalt pavements, with many illustrations of asphalt paved streets in various cities, together with maps and lists of streets in the principal cities of the United States, showing the extent to which asphalt pavements have been introduced.

New York Central and Hudson River Railroad, New York—Four Track Series, No. 10. Pamphlet descriptive of the attractions of the Thousand Islands and the St. Lawrence river, with map and much general information.

Charles E. Billin & Co., Chicago, Ill., U. S. A.—General catalogue of machinery and supplies for mines and mills, being pages 485 to 572 of the general serial catalogue issued by this firm, and containing, in addition to the goods listed, extracts from various sources of information in regard to mining machinery and appliances.

Electric Storage Battery Co., Philadelphia, Pa., U. S. A.—Illustrated pamphlet describing the installation of chloride accumulators in the criminal court building, New York City; with diagram showing the manner in which the battery assists in equalizing the load upon the engine.

The Bullock Electric Co., Cincinnati, Ohio, U. S. A.—Handsomely illustrated catalogue of Bullock electric generators and motors, with examples of numerous applications of electric driving by direct connection to various machine tools and other machinery.

Rand Drill Co., New York—Advance sheets of 1899 catalogue, illustrating and describing air and gas compressors, with many illustrations of existing installations, and tabulated information concerning numerous styles and sizes of compressors.

Waterbury Rope Co., New York—Pamphlet catalogue about rope and rope-making, with especial reference to rope for transmission and hoisting. An account of the gathering of the material and processes of manufacture is given, together with useful information concerning weights and strength of various sizes.

Pittsburgh Feed-Water Heater Co., Pittsburgh, Pa., U. S. A.—Catalogue of Pittsburgh feed-water heaters, both open and closed, with descriptions of the different types, and numerous testimonials from users.

Westinghouse Electric & Mfg. Co., Pittsburgh, Pa., U. S. A.—Detail catalogues (*a*) of the Westinghouse direct-current fan motor; (*b*) of the Westinghouse alternating-current fan motors; and (*c*) of the Wurts non-arcing lightning arresters.

The Winton Motor Carriage Co., Cleveland, Ohio, U. S. A.—Neat pamphlet containing an account of the recent trip of a Winton motor carriage from Cleveland to New York, a distance of more than 700 miles. An illustrated description and price-list of the various types of Winton vehicles is appended.

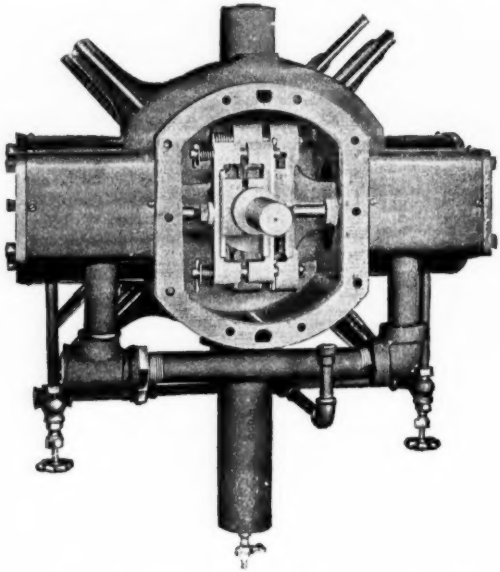
IMPROVED MACHINERY,

New Processes, and New Appliances.

The matter here published is not paid for, nor can it be classed as advertising. But as the information is necessarily obtained from those who offer the appliances for sale, it is proper to say that the manufacturers, rather than ourselves, are responsible for the statements made.

A New Engine.

THE American Blower Co., Detroit, Mich., is placing on the market a new combination in the shape of a steam engine directly connected to a ventilating fan. The feature of special note is the design of the engine, which is on new lines. It is a single-acting, reciprocating engine with



piston valves, which cut off at about one-half stroke, making it as economical in the use of steam as high grade non-condensing engines. Steam is admitted to the outer ends of the cylinders. The crank-pin brasses are fitted into an oblong yoke which is cast in one piece with the two pistons on each end. This yoke forms the ways in which the crank pin brasses slide up and down, and as the steam is admitted alternately to the two cylinders, a horizontal reciprocating motion is imparted to the yoke, which is converted into a rotary motion by the crank brasses sliding up and down in the yoke as above stated. The fan wheel acts as a fly wheel to carry the crank over the centers. As these wheels are always of large diameter, they make very good fly wheels. The yoke above mentioned is cut into halves, with a steel pin running through the top and bottom ends to keep each half in line. These pins are longer than the width of the yoke, and have spiral springs fitted over them at one end, held on by the belt head at one end and the yoke at the other. Just enough compression is given to the spring to hold the two halves of the yoke in their normal position

when the steam is shut off, and not let the crank pin brasses fall out. When the engine is running the steam pressure on the pistons keeps the brasses up snug against the crank pin.

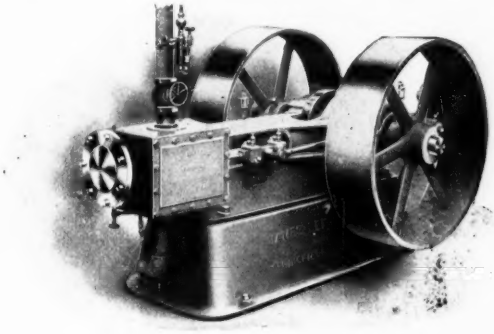
As there is a space of nearly a quarter of an inch between the half yokes, any wear of the crank pin or brasses is taken up, and will continue to be taken up, until the ends of the yoke come together, or are worn out. The valve mechanism is of the same construction as the other running gear only proportionately smaller. Every running part of the engine is lubricated from the chamber, as the crank and other working parts churn the oil and water into a foam, deluging everything within the case. This gives the pistons, valves and journals a bath of oil, not even a cylinder lubricator being required in addition. As more or less condensation always works by the pistons into the oil chamber, traps and settling pockets are provided for the separation of the oil from entrained water below the oil chamber, when the oil and water are not being agitated, and channels lead from this to a pocket at the top of the chamber so as to equalize the pressures, prevent syphoning and drain the water off automatically at a certain point to prevent overfilling of the chamber.

The manufacturers will be glad to give detailed information to inquirers.

The Leffel Engine.

THE accompanying illustration represents the class "B" standard center crank automatic cut-off engine being put on the market by James Leffel & Co., Springfield, O. They are intended to meet the demand for a thoroughly good, simple and easily-cared-for line of automatic engines in sizes up to 50 horse power, that will prove durable and economical in operation.

The bed is of substantial proportions, and of a design affording extra strength and stiffness. The cylinder and steam chest are of overhanging type, cast together, and firmly bolted to bed. The cross-head guides are a part of bed, bored out, and have very generous surface. The cross-head is of improved mechanical design, having the pin about mid-center, and provided with gun metal wedge-shaped shoes above and below, arranged for convenient adjustment. The manner of fitting



the cross-head pin enables easy adjustment at all times. The piston-rod is of steel, and is turned to a tight force fit in piston, with suitable shoulder, against which the piston is forced on the rod, and the end of latter is then securely riveted over, tightly and firmly holding the piston in place. The connecting-rod is provided with extra heavy brass boxes at each end, easily adjustable for taking up wear and keeping the distance between centers same at all times. The main shaft is extra large and strong, forged in one solid piece, from best quality hammered iron or steel, and is provided with suitable counter balance discs, securely attached. The rectangular form of skeleton slide valve is used, balanced by being fitted with a pressure-relieving plate on the back between the valve and steam chest lid, and is arranged to afford necessary relief in case of water in the cylinder.

A simple and convenient device (not

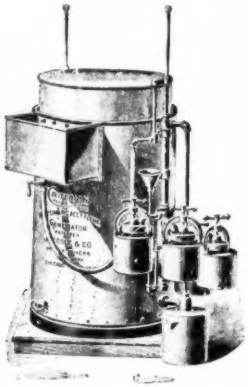
shown in cut) is provided for draining the cylinder, it being operated by a lever and having an outlet from each cylinder cock suitably connected to exhaust the pipe.

These engines are equipped with Rite's governing system.

The manufacturers will be pleased to furnish any additional information desired regarding these engines.

The "Criterion" Acetylene Gas Generator.

WHEREVER common gas is in use acetylene may be substituted with no trouble beyond the introduction of a generator and the adjustment of new burners. The engraving illustrates one of the latest styles of acetylene gas generators manufactured by J. B. Colt & Co., New York, for lighting dwellings, out-buildings, hotels, churches, theatres, public buildings and



manufacturing plants. This machine, known as the "Criterion," Model A, embodies in its construction the same general characteristics of all generators of this make. Some changes are noticed, however, in the Model A which have been made to meet the requirements of the several state boards of fire-insurance underwriters operating in the east, and which fit it especially for use in that section of the country.

Described briefly, it consists of a gasometer for regulating the supply of water, keeping the gas pressure constant and taking care of the surplus gas, and a large upright pipe support for carrying the four carbide holders. This support is attached to the gasometer by braces at top and bottom. An automatic trap or wash bottle which acts as a condenser for washing, cooling and purifying the gas after it is made and before it goes to the gasometer, is located at the bottom and to one side of the gasometer tank. On one side of the gasometer near the top is placed a water tank from which the supply of water is taken. The carbide holders are made in various sizes and are attached to the supporting upright by radial arms which extend from it, each holder being on a different level.

The automatic arrangements whereby the production of gas and the regulation of its flow are governed are positive in their action, and no gas is wasted.

Owing to the somewhat different insurance regulations in various parts of the country, another form of generator styled "Model C," is built, which embodies the same general principle of the sub-division of the carbide charge as Model A, but is of quite different mechanical construction.

The "Criterion" automatic acetylene gas generators have received the written approval of various boards of fire-insurance underwriters, covering every section of the United States, thus establishing their perfect safety. They have too, the endorsement of the United States government.

The manufacturers will gladly send further description and complete catalogues to interested parties.

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THE ENGINEERING MAGAZINE

DEVOTED SPECIALLY TO THE INTERESTS OF ACTIVE & CONSULTING ENGINEERS & WORKS MANAGERS.

EDITED BY JOHN R. DUNLAP,
CHARLES B. GOING, AND HENRY HARRISON SUPLEE.

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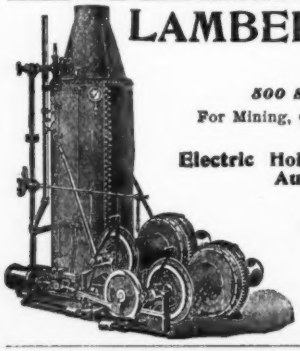

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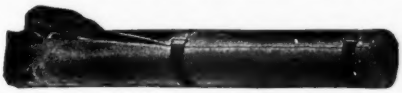

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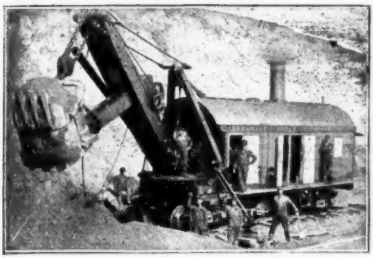

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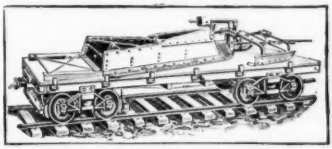

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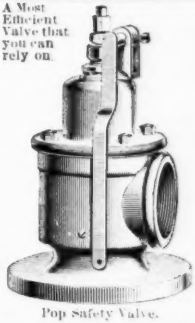

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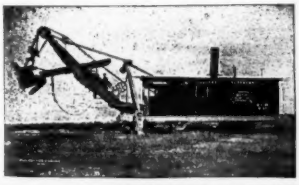

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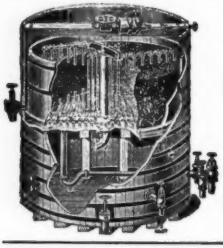

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AUTHORS AND PAPERS FOR SEPTEMBER.

HON. JOHN BARRETT (*America, England and Germany as Allies for the Open Door*)—Late United States Minister to Siam, and regarded as one of the best American authorities on far eastern questions. He is a descendant of an old Massachusetts family, more recently resident in Vermont; a graduate of Vermont and Worcester Academies, and B. A. of Dartmouth College (1889) where he made a special study of economics and politics. For some years pursued the study of international law and relations, traveling through the Southern States, South America, Europe, Asia and Hawaii, and publishing the result of his observations in various periodicals. He was appointed Minister to Siam by President Cleveland in 1894, and there scored an important diplomatic success in the settlement of the Cheek case, in which Sir Nicholas Hannen was arbitrator. Leaving his post in May, 1898, Mr. Barrett went to Manila, renewing observations made some years before. Since that time he has traveled in China and Japan, studying political and commercial conditions. He has lately addressed, by invitation, the Chambers of Commerce of Shanghai, Hong Kong, and the State of New York, and the Colonial party of the House of Commons, upon political and trade relations in the far east, and especially the interest and policy of the United States, and has written essays upon the same topic for the leading literary magazines and reviews of England and the United States.

ROBERT S. HALE *(Economy in the Use of Superheated Steam)*—Born in Boston, Mass., 1869. Graduate of the Roxbury Latin School, 1887; Harvard University, A. B., 1891, and A. M., 1892, and of Sibley College, Cornell University, M. E., 1893. Testing engineer for the Boston Edison Company, 1893 to 1895. Expert for the Steam Users' Association, 1895 to 1896. At present member of the firm of R. S. Hale & J. S. Codman, consulting engineers to the Mutual Boiler Insurance Company of Boston, and also engaged in electrical business.

RUDOLPH HAACK *(The Development of German Shipbuilding)*—Born in 1833, at Wolgast, in the Province of Pomerania; apprentice in shipbuilding, 1849; 1853-1854, pupil in the ship-building school at Grabow, near Stettin, and, after two years' experience as assistant in wooden-ship construction at Damgarten, entered as designing engineer in the ship building establishment of Furchtenicht & Broch, which, in 1857, was converted into the Stettin Machine Building Company "Vulcan," at Bredow, near Stettin. Being made Director of this works in 1873, he there constructed the first German-built armoured vessel, "Preussen," followed by a large number of all kinds of vessels for naval, passenger, and freight service. In 1887 he left the service of the Vulcan works, and established himself as consulting civil engineer in Berlin. Member of the *Königlichen Akademie des Bauwesens, the Kaiserlichen Ober-Seeamtes,* and the *Technischen Kommission für Seefahrt.*

P. J. DARLINGTON *(Systems for the Remuneration of Labor)*—Born in Philadelphia, 1869; educated at Pennsylvania State College and at Sibley College, Cornell University; engaged at William Sellers & Co.'s, Philadelphia, in connection with the erection of large gun lathes for the Washington Navy Yard, also at Bement, Miles & Co.'s, Philadelphia, upon construction of heavy shipbuilding equipment for the Newport News Company; subsequently in the drawing room of William Cramp & Sons' Company, working upon details of engines for the St. Paul and St. Louis, after which he became engineer's clerk on the International Navigation Company to study the performance of modern marine equipment, including quadruple-expansion engines, high-pressure boilers, forced-draft and modern auxiliary machinery. At present superintendent of the Royal Electric Company, of

Montreal, in which capacity he has had charge of the completion and installation of the generators of the Chambly Manufacturing Company; has had widely extended opportunities of studying shop systems, both from the workman's and employer's standpoint, and has for the past three years operated a piece-work system side by side with day work on a large variety of repair and special work, and is thus fully qualified by experience to treat the subject.

BENJAMIN TAYLOR *(The Water Supply of the City of Glasgow)*—A close observer and student of the broad influence of engineering progress and the economic effects of mchanical improvement. He is a contributor to many of the best periodicals, British and American. He is a Fellow of the Royal Geographical Society, a resident of Glasgow, and in close touch with the important engineering undertakings, accomplished or proposed, in Scotland.

THOMAS TONGE *(Electricity in the Mines at Cripple Creek)*—Born at Styal, near Manchester, England, in which city he was connected with the legal profession from 1861 to 1883; in that year, by the advice of his physician, he moved to Denver, Colo., where he became an American citizen; since 1883 he has made a special study of questions affecting the mining interests, especially, of Colorado, and the statistics of the gold and silver districts of the western United States, on which he has for years past been regarded as one of the leading, best-informed, and most reliable authorities; during his residence in Denver he has been a frequent contributor to the mining press of England and the United States. His article in this number was prepared after special visits to Cripple Creek for the purpose of studying the electric-power installations and equipment.

CHARLES ROUS-MARTEN *(American Locomotives on British Railways)*—The foremost British authority on the subject of increased railroad speeds, and a close and observant student of the mechanical improvements in motive power by which the successive advances have been secured. Mr. Rous-Marten's careful and accurate methods, which are original to himself, have given a confidence to his conclusions which is recognised by railroad men everywhere; he has contributed largely to the *Engineer* and other publications, and his work is as well known in the United States as it is in Great Britain. In preparing his recent articles in THE ENGINEERING MAGAZINE, Mr. Rous-Marten has had the advantage of consultation with the chief engineers of the lines which have lately ordered locomotives in the United States.

ALBERT SAUVEUR *(The Science of Metallography)*—Graduated from the Massachusetts Institute of Technology, 1889; spent two years in the chemical laboratory of the Penensylvania Steel Company, and six years with the Illinois Steel Company, being for five years in charge of the experimental laboratory of the latter company. At the present time he is the manager and proprietor of the Boston Testing Laboratory, editor of the *Metallographist*, and lecturer at the Massachusetts Institute of Technology. Mr. Sauveur is a member of a number of scientific and technical societies and author of many contributions relating to the subject of metallography and of the heat treatment and hardening of steel and allied subjects.

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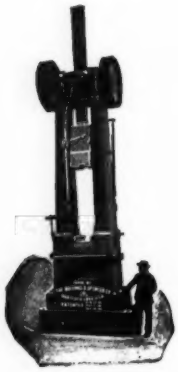

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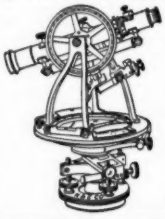

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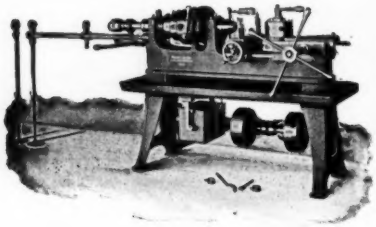

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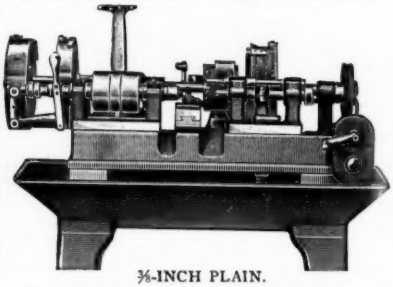

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Thorpe, Platt & Co., New York.
Robt. Wetherill & Co., Chester, Pa.

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Boiler Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Boiler Fronts and Fittings.
Vulcan Iron Works, Toledo, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Boiler Compounds.
Dearborn Drug & Chemical Works, 29 Rialto, Chicago, Ill.

Boiler Inspectors.
Hartford S. B. I. & Ins. Co., Hartford, Conn.

Boiler-Makers' Tools.
Hammacher, Schlemmer & Co., 209 Bowery, N.Y.
Stow Flexible Shaft Co., Philadelphia, Pa.

Bolt Cutters.
Acme Machinery Co., Cleveland, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Bolt and Rivet Headers.
Acme Machinery Co., Cleveland, Ohio.

Books.
Henry Carey Baird & Co., 810 Walnut St., Philadelphia, Pa.
Engineering Magazine Press, Ltd., 120-122 Liberty St., New York.

Boring Machines.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-279 West Front St., Cincinnati, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Box Makers' Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay Co., Cincinnati, Ohio.

Brass Working Machine Tools.
Warner & Swasey, Cleveland, Ohio.

Brewery Supplies.
Fred. W. Wolf Co., 139 Rees St., Chicago, Ill.

Bricks.
Henry Maurer & Son, 420 E. 23d St., New York.

Brick and Tile Machinery.
American Blower Co., Detroit, Mich.
F. D. Cummer & Son Co., Cleveland, Ohio.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

Bridge Builders.
Passaic Rolling Mill Co., Paterson, N. J.

Bridge Railing.
Chester B. Albree, Allegheny, Pa.

Builders' Elevators.
American Hoist & Derrick Co., St. Paul, Minn.
Lidgerwood Mfg. Co., 96 Liberty St., New York.

Building Materials.
Chester B. Albree, Allegheny, Pa.
T. H. Brooks Co., Cleveland, Ohio.
Cincinnati Corrugating Co., Piqua, Ohio.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
H. W. Johns Mfg. Co., 100 William St., N. Y.
Lawrence Cement Co., 1 Broadway, New York.
Henry Maurer & Son, 420 E. 23d St., New York.
Passaic Rolling Mill Co., Paterson, N. J.
Pittsburg Terra Cotta Lumber Co., Pittsburg, Pa.

Cable-Railway Driving-Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Robt. Wetherill & Co., Chester, Pa.

Cables, Electric and Submarine.
Okonite Co., Ltd., 253 Broadway, New York.

Cableways.
Fraser & Chalmers, Chicago, Ill.
Lidgerwood Mfg. Co., 96 Liberty St., New York

Cables, Wire.
American Hoist & Derrick Co., St. Paul, Minn.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
Trenton Iron Co., Trenton, N. J.

Calcining and Drying Machines.
F. D. Cummer & Son Co., Cleveland, Ohio.

Calculating Machines.
Felt & Tarrant Mfg. Co., Chicago, Ill.

Cams and Tappets.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.

Card Index Files.
Globe Company, Cincinnati, Ohio.

Car Shop Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.

Carriage and Wagon Machinery.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Eagan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Cast Iron Pipe.
U. S. Cast Iron Pipe & Fdy. Co., Philadelphia, Pa.

Castings, Iron and Steel.
Aultman Company, Canton, Ohio.
Edw. P. Allis Co., Milwaukee, Wis.
Chrome Steel Works, Brooklyn, N. Y.
Stanley G. Flagg & Co., Philadelphia, Pa.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Taunton Locomotive Mfg. Co., Taunton, Mass.
Walworth Manufacturing Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Cement.
Atlas Cement Co., 143 Liberty St., New York.
Kelley Island Lime and Transport Co., Cleveland, Ohio.
Lawrence Cement Co., 1 Broadway, New York

Centrifugal Pumps.
Bucyrus Co., So. Milwaukee, Wis.

Centrifugals.
Henry G. Morris, Philadelphia, Pa.

Cesspool Cleaning Apparatus.
Odorless Excavating Co., Boston, Mass.

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Chain Belting.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.

Chain Hoists.
Chisholm & Moore Mfg. Co., Cleveland, Ohio

Chemical Works Machinery.
Atlantic Works, East Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Chemists, Manufacturing.
Roessler & Hasslacher Chemical Co., New York.

Chemists—Water and Oil.
Dearborn Drug & Chemical Works, 29 Rialto, Chicago, Ill.

Chloride of Lime.
Roessler & Hasslacher Chem. Co., 100 William St., New York.

Chucks.
Pratt Chuck Co., Frankfort, N. Y.

Clay-Working Machinery.
Aultman Company, Canton, Ohio.
F. D. Cummer & Son Co., Cleveland, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
Vulcan Iron Works, Toledo, Ohio.

Coal and Ashes-Handling Machinery.
Aultman Company, Canton, Ohio.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., 147-149 Cedar St., New York.

Coal-Mining Machinery.
Buffalo Forge Co., Buffalo, N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
Arthur Koppel, 68 Broad St., New York.
John H. McGowan Co., Cincinnati, Ohio.
C. W. Hunt Co., 45 Broadway, New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, New York.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Sullivan Machinery Co., Chicago, Ill.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Coal Screens.
Harrington & King Perforating Co., Chicago, Ill.

Coal-Washing Machinery.
Jeffrey Mfg. Co., Columbus, Ohio.

Cold Saws.
Q & C Company, Chicago, Ill.

Compressed Air Hoists and Motors.
Stow Flexible Shaft Co., Philadelphia, Pa.

Compressed Air Shop Tools.
Clayton Air Compressor Works, 26 Cortlandt St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.

Concentrators and Pulverizers.
F. D. Cummer & Son Co., Cleveland, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Condensers.
Edw. P. Allis Co., Milwaukee, Wis.
Wm. Baragwanath & Son, Chicago, Ill.
Fraser & Chalmers, Chicago, Ill.
Laidlaw-Dunn-Gordon Co., Cincinnati, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Contractors.
A. B. Bowers, San Francisco, Cal.
Julian Kennedy, Pittsburg, Pa.

Contractors' Dump Cars, etc.
Gates Iron Works, Chicago, Ill.
Arthur Koppel, 68 Broad St., New York.

Contractors' Supplies.
American Hoist & Derrick Co., St. Paul, Minn.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., 147 Cedar St., N. Y.
Stearns Mfg. Co., Erie, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Vulcan Iron Works, Toledo, Ohio.
Watson & Stillman Co., 210 E. 43d St., New York.

Converters.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Conveying Machinery.
Aultman Company, Canton, Ohio.
Frick Company, Waynesboro, Pa.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., 147 Cedar St., N. Y.

Copper.
Canadian Copper Co., Cleveland, O.
Orford Copper Co., 37 Wall St., New York.

Corrugated Copper Tubes.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Corrugated Iron.
Cincinnati Corrugating Co., Piqua, Ohio.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Cranes.
American Hoist & Derrick Co., St. Paul, Minn.
Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Wm. Sellers & Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Crusher Plates.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Crushers—Ore, Phosphate, Rock.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
American Hoist & Derrick Co., St. Paul, Minn.

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Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Chrome Steel Works, Brooklyn, N. Y.

Cupolas.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Cyanide.
Roessler & Hasslacher Chemical Co., New York.

Cylinder Boring and Facing Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Dating Stamps.
Standard Time Stamp Co., 844 Washington St., New York.

Diamond Drills.
American Well Works, Aurora, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Sullivan Machinery Co., Chicago, Ill.
Rand Drill Co., 100 Broadway, New York.

Dies and Die Forgings.
Walworth Manufacturing Co., Boston, Mass.

Die and Drill Steel.
Chrome Steel Works, Brooklyn, N. Y.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.

Digesters.
Atlantic Works, East Boston, Mass.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Drawing Instruments and Materials.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Keuffel & Esser Co., New York.
Queen & Co., Inc., Philadelphia, Pa.

Dredging Machines.
Aultman Company, Canton, Ohio.
A. B. Bowers, San Francisco, Cal.
Bucyrus Co., So. Milwaukee, Wis.
Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, N. Y.
Vulcan Iron Works, Toledo, Ohio.

Drill Grinder.
G. T. Eames Co., Kalamazoo, Mich.

Drills—Rock and Coal.
American Hoist & Derrick Co., St. Paul, Minn.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
M. C. Bullock Mfg. Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Rand Drill Co., 100 Broadway, New York.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Drilling Machines.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Bickford Drill and Tool Co., Cincinnati, Ohio.
Buffalo Forge Co., Buffalo, N. Y.
Cincinnati Milling Machine Co., Cincinnati, O.
Fox Machine Co., Grand Rapids, Mich.
Niles Tool Works, Hamilton, Ohio.
Norton & Jones Machine Tool Works, Plainville, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Drop Forging Plants.
Billings & Spencer Co., Hartford, Conn.

Drop Hammers.
Billings & Spencer Co., Hartford, Conn.
Long & Allstatter Co., Hamilton, Ohio.

Drying and Calcining Machines.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
F. D. Cummer & Son Co., Cleveland, Ohio.
Gates Iron Works, Chicago, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.

Dump Cars.
Goodwin Car Co., 96 Fifth Ave., New York.

Dust Collectors.
Arlington & Curtis Co., 1639 Monadnock, Chicago, Ill.

Dynamos.
American Engine Co., Bound Brook, N. J.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
C & C Electric Co., 113 Liberty St., New York.
Commercial Electric Co., Indianapolis, Ind.
Eddy Electric Mfg. Co., Windsor, Conn.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Sprague Electric Co., 20 Broad St., New York.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Electrical Machinery and Supplies.
American Engine Co., Bound Brook, N. J.
Bristol Co., Waterbury, Conn.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
C & C Electric Co., 143 Liberty St., New York.
Commercial Electric Co., Indianapolis, Ind.
Eddy Electric Mfg. Co., Windsor, Conn.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Queen & Co., Inc., Philadelphia, Pa.
Wm. E. Quimby, 86 Liberty St., New York.
Sprague Electric Co., 20 Broad St., New York.
B. F. Sturtevant Co., Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Weston Electrical Instrument Co., Newark, N. J.

Electric Locomotives.
Baldwin Locomotive Works, Philadelphia, Pa.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
H. K. Porter Co., Pittsburg, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Elevator Buckets.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.

Elevator Guards and Screens.
Harrington & King Perforating Co., Chicago, Ill.

Elevators.
Gates Iron Works, Chicago, Ill.
Morse, Williams & Co., Philadelphia, Pa.
Sprague Electric Co., 20 Broad St., New York.
Triumph Electric Co., Cincinnati, Ohio.
R. D. Wood & Co., Philadelphia, Pa.

Emery Wheels.
Carborundum Co., Niagara Falls, N. Y.

Emery-Wheel Machinery.
Stow Flexible Shaft Co., Philadelphia, Pa.

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Engineers.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engineers, Consulting.
Daniel Ashworth, 326 Fourth Ave., Pittsburg, Pa.
Blood & Hale, Boston, Mass.
L. H. Blood, 49 Pearl St., Hartford, Conn.
A. B. Bowers, San Francisco, Cal.
Madison Cooper, 410 No. First St., Minneapolis, Minn.
L. B. Darling, 79 Sabin St., Providence, R. I.
W. Dusedau, Brooklyn, N. Y.
Julian Kennedy, Pittsburg, Pa.
David Lamond, 710 Ferguson Block, Pittsburg, Pa.
N. Y. University Testing Laboratory, New York.
Alexander Potter, New York and Pittsburg.
C. L. Redfield, Chicago, Ill.
Sydney F. Reynolds, Torry, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Stillman & Hall, Ltd., 15 Wall St., New York.
Tower & Wallace, Townsend Bldg., New York.

Engineering Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Keuffel & Esser Co., New York.
Queen & Co., Inc., Philadelphia, Pa.

Engines, Blowing.
Edw. P. Allis Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Fraser & Chalmers, Chicago, Ill.
Sprague Electric Co., 20 Broad St., New York.

Engines—Gas, Gasoline, and Petroleum.
American Well Works, Aurora, Ill.
Aultman Company, Canton, Ohio.
Daimler Mfg. Co., Steinway, Long Island City, N. Y.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Struthers, Wells & Co., Warren, Pa.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engines, Marine.
Atlantic Works, East Boston, Mass.
Marine Iron Works, Station A, Chicago, Ill.

Engines, Stationary.
Edw. P. Allis Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
American Engine Co., Bound Brook, N. J.
American Well Works, Aurora, Ill.
Aultman Company, Canton, Ohio.
Ball Engine Co., Erie, Pa.
Buffalo Forge Co., Buffalo, N. Y.
Bullock Mfg. Co., M. C., Chicago, Ill.
Frick Company, Waynesboro, Pa.
Gates Iron Works, Chicago, Ill.
Harrisburg Foundry and Machine Co., Harrisburg, Pa.
Hooven, Owens & Rentschler Co., Hamilton, Ohio.
Slater Engine Co., Warren, Mass.
Star Drilling Machine Co., Akron, Ohio.
Stearns Manufacturing Co., Erie, Pa.
B. F. Sturtevant Co., Boston, Mass.
Webster, Camp & Lane Machine Co., Akron, Ohio.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Robert Wetherill & Co., Chester, Pa.

Engravers.
A. Mugford, 120 Liberty St., New York.

Excavators.
A. B. Bowers, San Francisco, Cal.
Aultman Company, Canton, Ohio.
Bucyrus Co., So. Milwaukee, Wis.
Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, New York.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Vulcan Iron Works, Toledo, Ohio.

Exhaust Heads.
Direct Separator Co., Syracuse, N. Y.

Fans, Cooling and Heating.
Sprague Electric Co., 20 Broad St., New York.

Fans, Ventilating.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Fraser & Chalmers, Chicago, Ill.
Sprague Electric Co., 20 Broad St., New York.
B. F. Sturtevant Co., Boston, Mass.

Feed-Water Heaters.
Edw. P. Allis Co., Milwaukee, Wis.
Broomell, Schmidt & Co., York, Pa.
Fraser & Chalmers, Chicago, Ill.
Goubert Mfg. Co., 14 Church St., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Taunton Locomotive Mfg. Co., Taunton, Mass.
Robt. Wetherill & Co., Chester, Pa.

Feed-Water Purifiers.
Fraser & Chalmers, Chicago, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.

Ferro-Silicon.
Carborundum Co., Niagara Falls, N. Y.

Fertilizer Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.

Files.
Nicholson File Co., Providence, R. I.

Filters.
New York Filter Mfg. Co., New York.

Fire Hydrants.
R. D. Wood & Co., Philadelphia, Pa.

Flexible Shafts.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Floor and Sidewalk Lights.
T. H. Brooks & Co., Cleveland, Ohio.

Flour-Mill Machinery.
Edw. P. Allis Co., Milwaukee, Wis.

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Flue Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Fly Wheels.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.

Forges.
Buffalo Forge Co., Buffalo, N. Y.

Forgings, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Billings & Spencer Co., Hartford, Conn.
Keystone Drop Forge Co., Philadelphia, Pa.
Strieby & Foote, Newark, N. J.
Wyman & Gordon, Worcester, Mass.

Forming Machines.
Long & Allstatter Co., Hamilton, Ohio.

Friction Clutches.
Eastern Machinery Co., New Haven, Conn.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
Reeves Pulley Co., Columbus, Ind.

Furnace Builders.
Julian Kennedy, Pittsburg, Pa.

Furniture.
Globe Company, Cincinnati, Ohio.

Furniture and Chair Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.

Gages—Pressure, Steam, Water, etc.
Bristol Co., Waterbury, Conn.
Walworth Manufacturing Co., Boston, Mass.

Gas Fixtures.
Walworth Manufacturing Co., Boston, Mass.

Gas Holders.
Riter-Conley Mfg. Co., Pittsburg, Pa.
United Gas Improvement Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Gas Machines and Generators.
American Gas Furnace Co., 23 John St., N. Y.
J. B. Colt & Co., Dept. D. 5., 3-7 W. 29th St., New York.
United Gas Improvement Co., Philadelphia, Pa.
Walworth Manufacturing Co., Boston, Mass.

Gas Plants.
American Gas Furnace Co., 23 John St., New York.
J. B. Colt & Co., Dept. D. 5., 3-7 W. 29th St., New York
Riter-Conley Mfg. Co., Pittsburg, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gas Producers.
Riter-Conley Mfg. Co., Pittsburg, Pa.
United Gas Improvement Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Gas-Works Machinery.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gate Valves.
Jenkins Bros., 71 John St., New York.
Walworth Manufacturing Co., Boston, Mass.

Gear Cutters.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Gearing.
Edw. P. Allis Co., Milwaukee, Wis.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.
Morse, Williams & Co., Philadelphia, Pa.
New Process Rawhide Co., Syracuse, N. Y.
Stow Flexible Shaft Co., Philadelphia, Pa.

Girders
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Glass Polishing Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Grain Elevator Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Robins Conveying Belt Co., 147-149 Cedar St., New York.

Grates.
Vulcan Iron Works, Toledo, Ohio.

Grinding and Polishing Machinery.
Landis Tool Co., Waynesboro, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.

Grips, Cable Railways.
Robt. Wetherill & Co., Chester, Pa.

Hangers—See Pulleys.

Heating and Ventilating Apparatus.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Sprague Electric Co., 20 Broad St., New York.

Heaters, Steam and Hot Water.
Gorton & Lidgerwood Co., 96 Liberty St., N. Y.
H. B. Smith Co., 137 Center St., New York.
Walworth Manufacturing Co., Boston, Mass.

Helve Hammers.
Long & Alstatter Co., Hamilton, Ohio.

Hoisting Engines and Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
Aultman Company, Canton, Ohio.
Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

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Stearns Manufacturing Co., Erie, Pa.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Webster, Camp & Lane Machine Co., Akron, O.

Hollow Bricks.
Henry Maurer & Son, 420 E. 23d St., New York.
Pittsburg Terra Cotta Lumber Co., Pittsburg, Pa.

Hollow Chisel Mortisers.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.

Hydrants.
R. D. Wood & Co., Philadelphia, Pa.

Hydraulic Cement.
Atlas Cement Co., 143 Liberty St., New York.
Kelley Island Lime and Transport Co., Cleveland, Ohio.
Lawrence Cement Co., 1 Broadway, New York.

Hydraulic Machinery.
John H. McGowan Co., Cincinnati, Ohio.
Watson & Stillman Co., 210 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Ice-Making Machinery.
Frick Company, Waynesboro, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Stilwell, Bierce & Smith-Vaile Co., Dayton, O.
Vilter Manufacturing Co., Milwaukee, Wis.
Westinghouse Machine Co., Pittsburg, Pa.
Fred. W. Wolf Co., 139 Rees St., Chicago, Ill.

Ice and Refrigeration.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Fred W. Wolf Co., 139 Rees St., Chicago, Ill.

Impulse Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Incandescent Lamps.
Sawyer-Man Electric Co., New York.

Indexing Systems.
Globe Co., Cincinnati, Ohio.

Indicators, Steam-Engine.
Queen & Co., Inc., Philadelphia, Pa.

Industrial Railways.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Injectors.
American Injector Co., Detroit, Mich.
Wm. Sellers & Co., Philadelphia, Pa.

Insulated Wire.
Okonite Co., Ltd., 253 Broadway, New York.

Insulating Varnish.
Sterling Varnish Co., Pittsburg, Pa.

Interior Conduits.
Sprague Electric Co., 20 Broad St., New York.

Iron.
Passaic Rolling Mill Co., Paterson, N. J.

Joists, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Passaic Rolling Mill Co., Paterson, N. J.

Kiers.
Atlantic Works, East Boston, Mass.

Kyanizing.
Otis Allen & Son, Lowell, Mass.

Lamps, Electric.
J. B. Colt & Co., Dept. D. 5., 3-7 W. 29th St., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Lathes.
U. Baird Machinery Co., Pittsburg, Pa.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Cincinnati Milling Machine Co., Cincinnati, O.
Jones & Lamson Machine Co., Springfield, Vt.
Niles Tool Works, Hamilton, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Launches—Steam, Naphtha, etc.
Daimler Mfg. Co., Steinway, Long Island City, N. Y.
Marine Iron Works, Station A, Chicago, Ill.

Link Belting.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.

Locomotives.
Baldwin Locomotive Works, Philadelphia, Pa.
Pittsburg Locomotive Works, Pittsburg, Pa.
H. K. Porter Co., Pittsburg, Pa.
Stearns Manufacturing Co., Erie, Pa.

Locomotive Brakes.
Westinghouse Air Brake Co., Pittsburg, Pa.

Locomotive Cranes.
Bucyrus Co., So. Milwaukee, Wis.

Lubricants.
Jos. Dixon Crucible Co., Jersey City, N. J.

Machine Screws.
Worcester Machine Screw Co., Worcester, Mass.

Machine Tools and Supplies.
Acme Machinery Co., Cleveland, Ohio.
U. Baird Machinery Co., Pittsburg, Pa.
W. F. & John Barnes Co., Rockford, Ill.
Edwin E. Bartlett, Boston, Mass.
Bement, Miles & Co., Philadelphia, Pa.
Billings & Spencer Co., Hartford, Conn.
Cincinnati Milling Machine Co., Cincinnati, O.
Fox Machine Co., Grand Rapids, Mich.
Hammacher, Schlemmer & Co., 209 Bowery, N.Y.
Jones & Lamson Machine Co., Springfield, Vt.
Niles Tool Works, Hamilton, Ohio.
Norton & Jones Machine Tool Works, Plainville, Conn.
O & C Company, Chicago, Ill.
Wm. Sellers & Co., Philadelphia, Pa.
Stearns Manufacturing Co., Erie, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Walworth Manufacturing Co., Boston, Mass.
Warner & Swasey, Cleveland, Ohio.
Worcester Machine Screw Co., Worcester, Mass.

Magic Lanterns.
J. B. Colt & Co., Dept. D. 5., 3-7 W. 29th St., New York.

Marine Boilers.
Marine Iron Works, Station A, Chicago, Ill.

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A BUYERS' DIRECTORY.

Marine Machinery.
Lambert Hoisting Engine Co., Newark, N. J.
Marine Iron Works, Station A, Chicago, Ill.

Mathematical Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Queen & Co., Inc., Philadelphia, Pa.

Mechanical Draft.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Merchant Steel.
Wm. Jessop & Sons, Ltd., 91 John St., N. Y.

Metals.
Passaic Rolling Mill Co., Paterson, N. J.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Metal Lath.
Cincinnati Corrugating Co., Piqua, Ohio.

Metal Punching and Shearing.
Harrington & King Perforating Co., Chicago, Ill.

Meters, Electric.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Milling Machines.
Bement, Miles & Co., Philadelphia, Pa.
Cincinnati Milling Machine Co., Cincinnati, O.
Fox Machine Co., Grand Rapids, Mich.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Mine Cars.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppell, 68 Broad St., New York.

Mining Machinery.
Edw. P. Allis Co., So. Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Arthur Koppel, 68 Broad St., New York.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
John H. McGowan Co., Cincinnati, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, New York.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Webster, Camp & Lane Machine Co., Akron, O.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Mining Screens.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.

Motors, Electric.
American Engine Co., Bound Brook, N. J.
C & C Electric Co., 145 Liberty St., New York.
Commercial Electric Co., Indianapolis, Ind.
Eddy Electric Mfg. Co., Windsor, Conn.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Sprague Electric Co., 20 Broad St., New York.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Multiple Drills.
Bickford Drill and Tool Co., Cincinnati, Ohio.

Naphtha Gas Machines.
American Gas Furnace Co., 23 John St., N. Y.

Nickel.
Canadian Copper Co., Cleveland, Ohio.
Orford Copper Co., 37 Wall St., New York.

Office Furniture.
Globe Company, Cincinnati, Ohio.

Oil Cups.
Walworth Manufacturing Co., Boston, Mass.

Oil Extractors.
Direct Separator Co., Syracuse, N. Y.

Oil Filters.
Burt Manufacturing Co., Akron, Ohio.

Oil-Gas Plants.
American Gas Furnace Co., 23 John St., N. Y.

Oil Separators.
Harrison Safety Boiler Works, Philadelphia, Pa.

Open Links.
Keystone Drop Forge Co., Philadelphia, Pa.

Ore-Dressing Machinery.
Fraser & Chalmers, Chicago, Ill.

Ore-Roasting Machinery.
F. D. Cummer & Son Co., Cleveland, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Ore Screens.
Harrington & King Perforating Co., Chicago, Ill.

Ornamental Iron Work.
Chester B. Albree, Allegheny, Pa.
Winslow Bros. Co., Chicago, Ill.

Packing.
Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., New York.
Peerless Rubber Mfg. Co., 16 Warren St., N. Y.

Paddle-Wheel Machinery.
Marine Boiler Works, Station A, Chicago, Ill.

Paints.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
Harrison Bros. & Co., Inc., Philadelphia, Pa.

Paper-Mill Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Robt. Wetherill & Co., Chester, Pa.

Pattern-Makers' Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.

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Pattern Makers' Tools.
Fox Machine Co., Grand Rapids, Mich.

Penstocks.
Atlantic Works, East Boston, Mass.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Perforated Metals.
Fraser & Chalmers, Chicago, Ill.
Harrington & King Perforating Co., Chicago, Ill.

Peroxide of Sodium.
Roessler & Hasslacher Chemical Co., New York.

Phosphor Bronze.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Photographic Supplies.
Queen & Co., Inc., Philadelphia, Pa.

Pile Drivers.
Bucyrus Co., So. Milwaukee, Wis.

Pipe, Cast-Iron.
Jeanesville Iron Works, Jeanesville, Pa.
Walworth Manufacturing Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.
U. S. Cast Iron Pipe & Fdy. Co., Philadelphia, Pa.

Pipe Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Pipe Coverings.
Michigan Pipe Co., Bay City, Mich.

Pipe-Cutting and Threading Machines.
Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Merrell Mfg. Co., 10 Curtis St., Toledo, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Pipe Dies.
Walworth Manufacturing Co., Boston, Mass.

Pipe Fittings, Cast-Iron.
Walworth Manufacturing Co., Boston, Mass.

Pipe, Wrought-Iron.
Walworth Manufacturing Co., Boston, Mass.

Placer Mining Machinery.
Bucyrus Co., So. Milwaukee, Wis.

Planers.
U. Baird Machinery Co., Pittsburg, Pa.
Bement, Miles & Co., Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Planing Mill Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.

Plumbers' Tools and Supplies.
Walworth Manufacturing Co., Boston, Mass.

Portable Railways.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Portland Cement.
Atlas Cement Co., 143 Liberty St., New York.

Power Hammers.
Bement, Miles & Co., Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Power Punches and Shears.
Fox Machine Co., Grand Rapids, Mich.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa

Power-Transmission Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Sprague Electric Co., 20 Broad St., New York.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Preservation of Lumber.
Otis Allen & Son, Lowell, Mass.

Presses, Hydraulic, etc.
Watson & Stillman Co., 210 East 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Propeller Wheels.
Marine Iron Works, Station A, Chicago, Ill.

Prospecting Drills.
American Well Works, Aurora, Ill.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Pulleys, Shafting and Hangers.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Reeves Pulley Co., Columbus, Ind.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Wm. Sellers & Co., Philadelphia, Pa.
Robert Wetherill & Co., Chester, Pa.

Pulverizers.
Fraser & Chalmers, Chicago, Ill.

Pumps and Pumping Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
Barr Pumping Engine Co., Philadelphia, Pa.
The Geo. F. Blake Mfg. Co., 91 Liberty St., New York.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Cook Well Co., St. Louis, Mo.
The Deane Steam Pump Co. of Holyoke, 120 Liberty St., New York.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Guild & Garrison, Brooklyn, N. Y.
The Holly Manufacturing Co., 120 Liberty St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Jeanesville Iron Works, Jeanesville, Pa.
John H. McGovern Co., Cincinnati, Ohio.
Knowles Steam Pump Works, 91 Liberty St., New York.
The Laidlaw-Dunn-Gordon Co., 120 Liberty St., New York.
Merrill Pneumatic Pump Co., 143 Broadway, New York.
Odorless Excavating Co., Boston, Mass.
Pulsometer Steam Pump Co., 120 Liberty St., New York.
Wm. E. Quimby, 86 Liberty St., New York.
Snow Steam Pump Works, 120 Liberty St., New York.
Stilwell-Bierce & Smith Vaile Co., Dayton, Ohio.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Webster, Camp & Lane Machine Co., Akron, Ohio.

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R. D. Wood & Co., Philadelphia, Pa.
Henry R. Worthington, 120 Liberty St., New York.

Punching and Shearing Machinery.
Bement, Miles & Co., Philadelphia, Pa.
G. T. Eames Co., Kalamazoo, Mich.
Fox Machine Co., Grand Rapids, Mich.
Long & Allstatter Co., Hamilton, Ohio.
New Doty Manufacturing Co., Janesville, Wis.

Quarrying Machinery.
American Hoist & Derrick Co., St. Paul, Minn.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
John H. McGowan Co., Cincinnati, Ohio.
Rand Drill Co., 100 Broadway, New York.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.

Radiator Screens.
Harrington & King Perforating Co., Chicago, Ill.

Radiators.
H. B. Smith Co., 137 Centre St., New York.

Radial Drills.
Bickford Drill and Tool Co., Cincinnati, Ohio.

Railroad Ditchers.
Jeffrey Mfg. Co., Cleveland, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Vulcan Iron Works, Toledo, Ohio.

Railway-Car Brakes.
Westinghouse Air Brake Co., Pittsburg, Pa.

Railway Feed Wires.
Okonite Co., Ltd., 253 Broadway, New York.

Railway Shop Machinery.
Chester B. Albree, Allegheny, Pa.
Armstrong Mfg. Co., Bridgeport, Conn.
W. F. & John Barnes Co. Rockford, Ill.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.
Niles Tool Works, Hamilton, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
O & C Company, Chicago, Ill.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Watson & Stillman Co., 210 E. 43d St., New York.

Railway Specialties.
Goodwin Car Co., 96 Fifth Ave., New York.
O & C Company, Chicago, Ill.
Arthur Koppel, 68 Broad St., New York.
H. K. Porter & Co., Pittsburg, Pa.,
Westinghouse Air Brake Co., Pittsburg, Pa.

Railways, Portable.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Rawhide Pinions.
New Process Rawhide Co., Syracuse, N. Y.

Refrigerating Machinery.
Frick Company, Waynesboro, Pa.
Vilter Manufacturing Co., Milwaukee, Wis.
Fred. W. Wolf Co., 139 Rees St., Chicago, Ill.

Riveting Machines.
Chester B. Albree, Allegheny, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Road-Making Machinery.
Aultman Co., Canton, Ohio.
O. S. Kelly Co., Springfield, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Road Rollers.
Aultman Co., Canton, Ohio.
O. S. Kelly Co., Springfield, Ohio.

Rock Breakers.
Aultman Co., Canton, Ohio.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Robins Conveying Belt Co., 147-149 Cedar St., New York.

Rock Drills.
American Hoist & Derrick Co., St. Paul, Minn.
M. C. Bullock Mfg. Co., Chicago, Ill.
Clayton Air Compressor Works, 26 Cortlandt St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Rand Drill Co., 100 Broadway, New York.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Roofing.
Cincinnati Corrugating Co., Piqua, Ohio.
Merchant & Co., Philadelphia, Pa.
Passaic Rolling Mill Co., Paterson, N. J.

Roofs, Iron Truss.
Passaic Rolling Mill Co., Paterson, N. J.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Rope Transmission.
Aultman Company, Canton, Ohio.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.

Rubber Goods.
Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., New York.

Saw-Mill Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.
Jeffrey Manufacturing Co., Columbus, Ohio.

Schools.
Armour Inst. of Technology, Chicago, Ill.
Harvard University, Cambridge, Mass.
International Correspondence Schools, Scranton, Pa.
Michigan College of Mines, Houghton, Mich.
Purdue University, Lafayette, Ind.
Rensselaer Polytechnic Institute, Troy, N. Y.

Screens, Mining.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Robins Conveying Belt Co., 147-149 Cedar St., New York.

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Screw Machines.
Cincinnati Milling Machine Co., Cincinnati O.
Jones & Lamson Machine Co., Springfield, Vt.
Niles Tool Works, Hamilton, Ohio.
Warner & Swasey, Cleveland, Ohio.

Sensitive Drills.
Fox Machine Co., Grand Rapids, Mich.

Separators, Coal and Ore.
F. D. Cummer & Son Co., Cleveland, Ohio.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Manufacturing Co., Columbus, Ohio.

Separators, Steam.
Direct Separator Co., Syracuse, N. Y.
Harrison Safety Boiler Works, Philadelphia, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Shafts—Flexible.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Shafting (see Pulleys).

Shapers.
Fox Machine Co., Grand Rapids, Mich.

Shaping Machines.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Cincinnati Shaper Co., Cincinnati, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Shoes and Dies.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Smokestacks.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Hazelton Boiler Co., 716 E. 13th St., New York.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Sodium Peroxide.
Roessler & Hasslacher Chem. Co., 100 William St., New York.

Spark Guards, Perforated.
Harrington & King Perforating Co., Chicago, Ill.

Stand Pipes.
Enterprise Boiler Co., Youngstown, Ohio.
Riter-Conley Mfg. Co., Pittsburgh, Pa.

Steam Loops.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Steam-Regulating Appliances.
Harrison Safety Boiler Works, Philadelphia, Pa.
Jenkins Brothers, 71 John St., New York.
B. F. Sturtevant Co., Boston, Mass.
Walworth Manufacturing Co., Boston, Mass.

Steamships and Towboats.
Atlantic Works, East Boston, Mass.

Steam Shovels.
Bucyrus Co., So. Milwaukee, Wis.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Steam Traps.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
B. F. Sturtevant Co., Boston, Mass.
Walworth Manufacturing Co., Boston, Mass.

Steel Importers.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.

Steel Manufacturers.
Chrome Steel Works, Brooklyn, N. Y.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.
Passaic Rolling Mill Co., Paterson, N. J.

Steel Stacks.
Enterprise Boiler Co., Youngstown, Ohio.

Stereopticons.
J. B. Colt & Co., Dept. D. 5., 3-7 W. 29th St., New York.

Stokers.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Structural Iron Work.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Sugar-House Machinery.
Henry G. Morris, Philadelphia, Pa.
Robins Conveying Belt Co., 147-149 Cedar St., New York.
Fred. W. Wolf Co., 139 Rees St., Chicago, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Surveying Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons & Co., Brooklyn, N. Y.
Keuffel & Esser Co., New York.
Queen & Co., Inc., Philadelphia, Pa.
Stackpole & Brother, 42 Fulton St., New York

Tanks.
W. E. Caldwell Co., Louisville, Ky.

Tanks, Iron.
Atlantic Works, East Boston, Mass.
Aultman Company, Canton, Ohio.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Enterprise Boiler Co., Youngstown, Ohio.
Hazelton Boiler Co., 716 E. 13th St., New York.
Pittsburg Locomotive Works, Pittsburg, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass

Tapping and Reaming Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Telegraph Wires and Cables.
Okonite Co., New York.

Tenoning Machines.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio

Testing Machinery.
Wm. Sellers & Co., Philadelphia, Pa.

Thermometers.
Bristol Co., Waterbury, Conn.
Queen & Co., Inc., Philadelphia, Pa.

Tie Plates.
Q & C Company, Chicago, Ill.

Time Stamps.
Standard Time Stamp Co., 843 Washington St., New York.

Tire-Welding Machine.
Long & Allstatter Co., Hamilton, Ohio.

Tramways.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

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Tramways, Wire Rope.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
W. Dusedau, 36 Pilling St., Brooklyn, N. Y.
C. W. Hunt Co., 45 Broadway, New York.
Trenton Iron Co., Trenton, N. J.

Trimmers.
Fox Machine Co., Grand Rapids, Mich.

Tube Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Turbines.
James Leffel & Co., Springfield, Ohio.
Pelton Water Wheel Co., San Francisco, Cal.
Westinghouse Machine Co., Pittsburg, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Turn Tables.
Passaic Rolling Mills Co., Paterson, N. J.
Wm. Sellers & Co., Philadelphia, Pa.

Turret Machinery.
Warner & Swasey, Cleveland, Ohio.

Twist Drills.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Vacuum Pans.
Henry G. Morris, Philadelphia, Pa.

Vacuum Pumps.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Clayton Air Compressor Works, 26 Cortlandt St., New York.
Deane Steam Pump Co., Holyoke, Mass.
Guild & Garrison, Brooklyn, N. Y.
John H. McGowan Co., Cincinnati, Ohio.

Valves—Gas, Steam, and Water.
Jeanesville Iron Works, Jeanesville, Pa.
Jenkins Brothers, 71 John St., New York.
John H. McGowan Co., Cincinnati, Ohio.
Walworth Mfg. Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Ventilating Appliances.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.

Voltmeters.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co.,, Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Watt Meters.
Buffalo Meter Co., Buffalo, N. Y.
Pittsburg Meter Co., East Pittsburg, Pa.

Water-Tube Boilers.
Hazelton Boiler Co., 716 E. 13th St., New York.
The Stirling Co., Chicago, Ill.

Water-Work-Supplies.
American Well Works, Aurora, Ill.
McNeil Pipe & Foundry Co., Burlington, N. J.
Star Drilling Machine Co., Akron, Ohio.

Water Wheels.
James Leffel & Co., Springfield, Ohio.
Pelton Water Wheel Co., San Francisco, Cal.
R. D. Wood & Co., Philadelphia, Pa.

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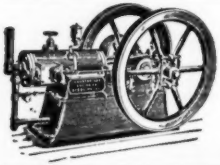

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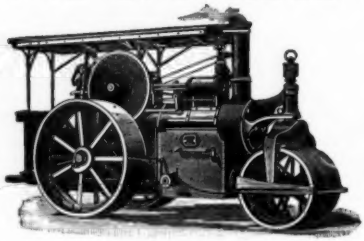

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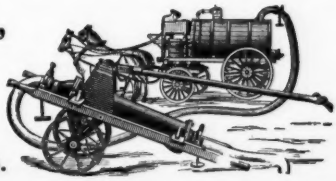

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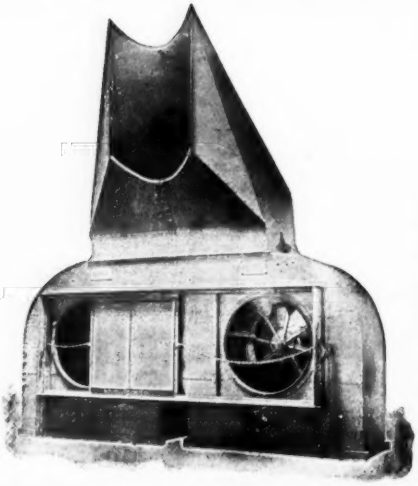

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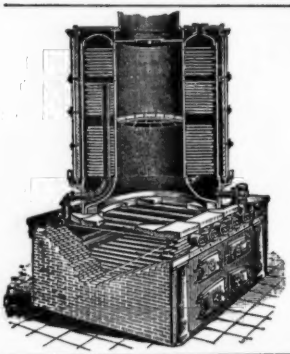

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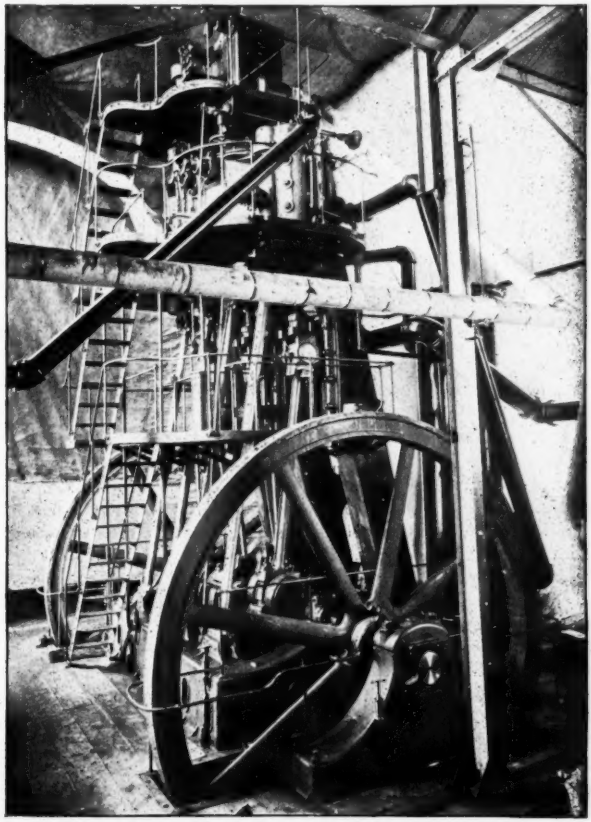
A Vertical Air Compressor.

THE Chicago Shipbuilding Co., has recently designed and built for their own use a vertical air-compressor, shown in half-tone illustration herewith. The machine is of the three crank type, with compound steam cylinders placed tandem over the center crank, and is operated condensing with a steam pressure of 125 pounds, the steam cylinders being respectively 19 and 42 inches diameter, 42-inch stroke. The air cylinders are placed over the outer cranks. The low pressure air cylinder is 33 inches in diameter, and the



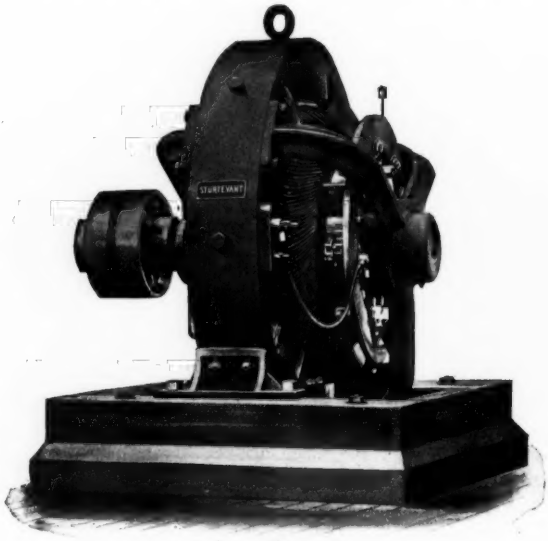
high pressure cylinder is 19 inches, the stroke of both being 42 inches.

The system of cooling employed is worth attention. The usual water jackets are provided on the cylinder, but a positive effective circulation is obtained by the manner of coring the jackets by which the cooling water is compelled to make the complete circuit of each cylinder four times. A large intercooler is provided, which is 45 inches in diameter and 13 feet 8 inches high containing 341 1¼-inch tubes, with 415 square feet of cooling surface. The cooling water enters first the jacket of the high pressure air cylinder, thence to the bottom of the intercooler, through the tubes of which it passes, and from the top it flows to the jacket of the low pressure air cylinder. The water is afterward used for boiler feed, thus utilizing the heat it absorbed in its passage through the machine. The air is compressed in the first cylinder to a pressure between 25 and 40 pounds, depending upon the speed at which the machine is operated, and is delivered to the intercooler, entering it at the top and leaving it at the bottom. There are thus no pockets or dead spaces in either the water or air passages through the intercooler, each flowing in the direction naturally due to its changing temperature. The quantity of water used is very small, and the efficiency of the arrangement is shown by the low temperature of the air at discharge, which is not over 125°. This will be lowered somewhat when the intake pipe is completed, so that the air will be taken from outside the building.

The machine is now compressing about 2,900 cubic feet per minute to 100 pounds at an average speed of 70 revolutions.

A New 8-Pole Generator and Motor.

In the accompanying illustration is presented a new type of 8-pole machine, which has been brought out by the B. F Sturtevant Co., of Boston, Mass., and, as indicated by the coupling, is primarily designed for direct connection to a shaft, usually the shaft of a fan.



The field ring, which constitutes the frame of this machine, is made of wrought-iron, cast-steel, or cast-iron, according to the size, the sizes ranging from 3-H. P. up to a 137.5 H. P. motor, or from a 3-K. W. generator up to a 110-K. W. generator.

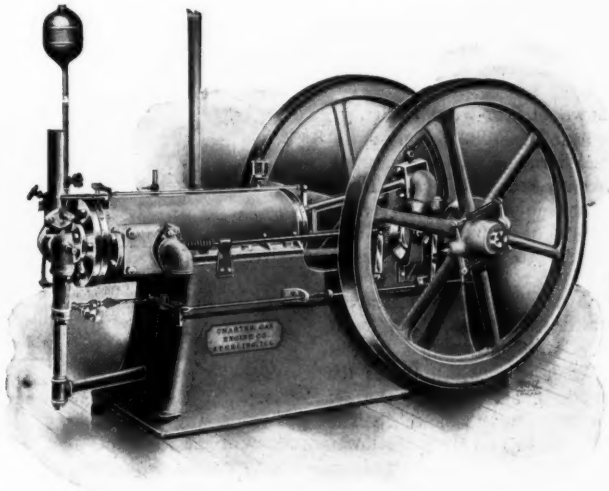
Wrought-iron field cores are used, and a special type of cast-iron pole shoe, which by its peculiar shape and size, is one of the principal elements in rendering this ma

chine capable of extreme variation of load without sparking of the brushes, or any shifting of adjustment whatever.

The field coils are machine wound, and this form of field being extremely open, the windings present the greatest amount of radiating surface, with consequent perfect ventilation. As these motors are designed with special reference to low speed and high efficiency special care has been taken in determining the size of the armature that would be favorable to high efficiency at partial loads, and at the same time allow room for the necessary amount of copper. The armature coils are built up of laminated, slotted discs, mounted upon a cast-iron spider, having a hub projection for the reception of the commutator. The core discs are solidly clamped between two brass rings, which have teeth to correspond with the core teeth, and which support them at both edges of the core, and not only protect the teeth from being damaged or misplaced, but present a smooth and well rounded corner for the support of the slot insulation.

These armatures are of the coil-wound drum type, and usually have the two-circuit winding, although in some cases a multiple winding is used. In the two circuit winding, there is opportunity for employing larger wire and fewer turns, thereby making the coil simpler and cheaper, while at the same time each coil has only a fractional influence on the total electric force generated, so that the electrical balance of the armature is readily maintained. The special feature of this type of winding lies in the fact that as few as two sets of brushes can be used.

The commutator is of large diameter, with rolled or drop-forged copper segments, supported in a cast-iron shell of spider construction, thoroughly insulated with mica and micanite. Owing to the design, but little energy is dissipated at the brushes, and overheating of the commutator is not likely to occur.



Reaction brushes of carbon are generally used, and supported on a special rigging, which is in turn carried by brackets, attached to the field ring. The tripod bearing yoke serves to support the shaft upon each side of the machine, and to render it independent. The bearings are provided with sleeves, which in the larger sizes are self-aligning, and ring oilers are used to secure positive and continuous lubrication.

Further details may be had from the manufacturers.

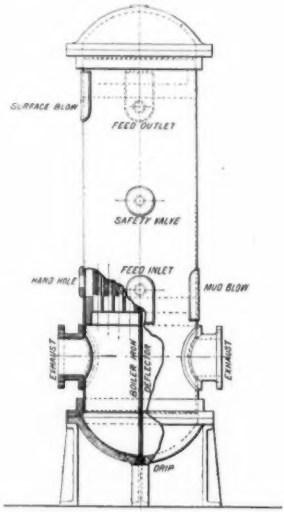
The Charter Gasoline Engine.

THE latest design of the "Charter" gasoline engine, shown in the accompanying

picture, is a graceful piece of machinery, and combines all of the excellencies that are obtained in the well-known "Charter" type of engines. This cut shows the improved electric igniter, the result of many years of experiment and practice. The Bunsen burner and tube igniter is also shown, as each engine is equipped with both igniters. The "Charter" is the pioneer gasoline engine of the western hemisphere, and has been fully kept up with the times, and is an up-to-date machine in all particulars. A pump to raise the gasoline from the tank below the engine and outside of the building, if desired, is furnished to purchasers. Catalogues and full particulars can be obtained by addressing the Charter Gas Engine Co., Sterling, Ill., U. S. A.

The Wainwright Feed-Water Heater.

THE accompanying illustration represents a special form of feed-water heater which has recently been built by the Taunton Locomotive Manufacturing Co. for the Fayal Iron Works of Minnesota. This is a steam tube heater so arranged that it is placed in the direct line of the exhaust steam pipe, the steam entering and leaving the heater at the same level. The lower steam chamber is provided with a deflecting plate of boiler iron which causes the exhaust steam to mount through one set of pipes and return through the other. The feed-water is admitted just above the lower tube sheet, and mounting to the top of the heater, is discharged to the boilers through an opening located just below the upper tube sheet. On a level with the exhaust inlet is placed a mud-blow and a hand-hole for inspecting purposes. The surface blow is situated on a level with the feed water outlet. While the general proportions of this heater are in line with the Wainwright standards, the arrangement is unique. It is remarkable that the peculiar features of the Wainwright apparatus are not dependent for their value upon any particular arrangement of the parts but may be



grouped in any manner to meet an unusual condition, without impairing the high efficiency of the apparatus as a whole.

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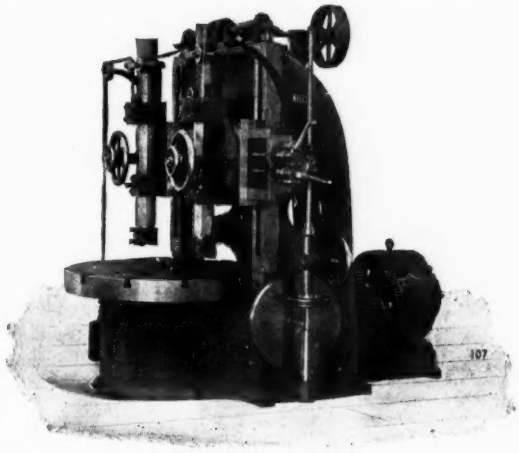

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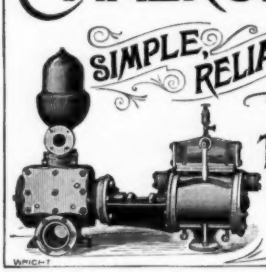

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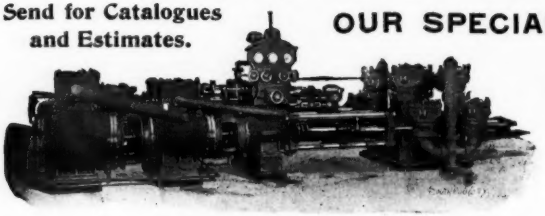

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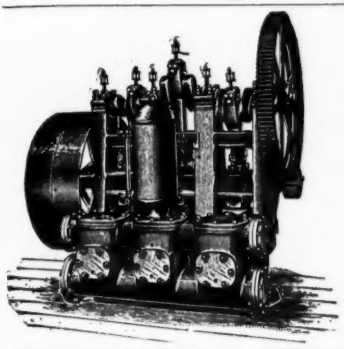

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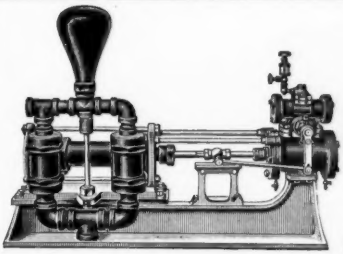

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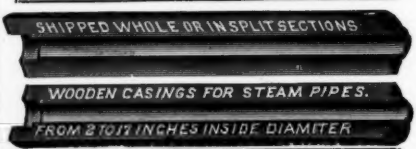

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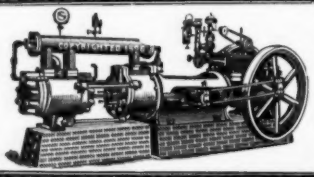

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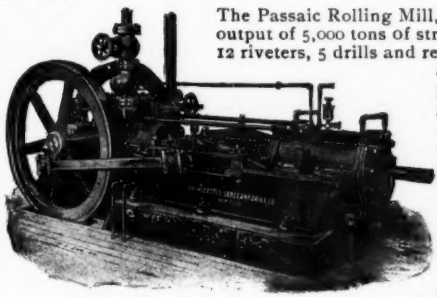

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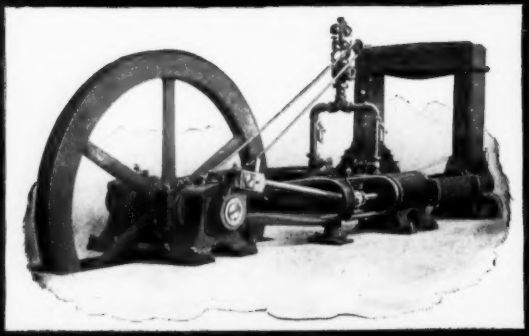

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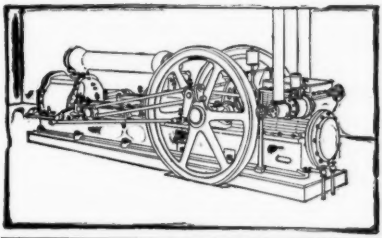

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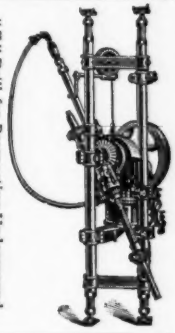

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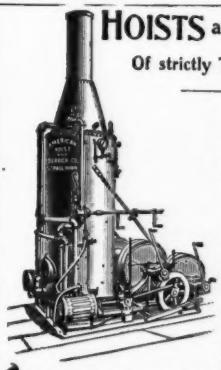

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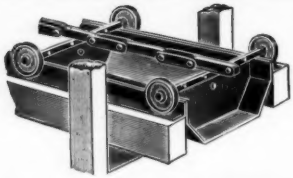

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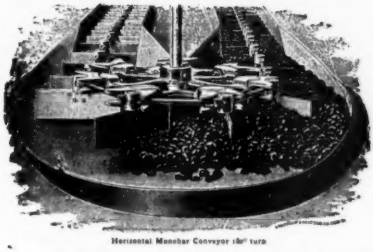

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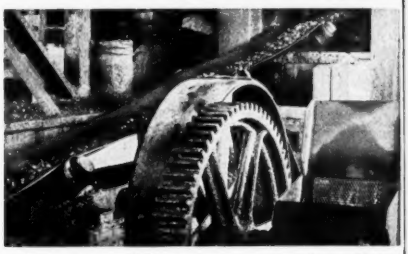

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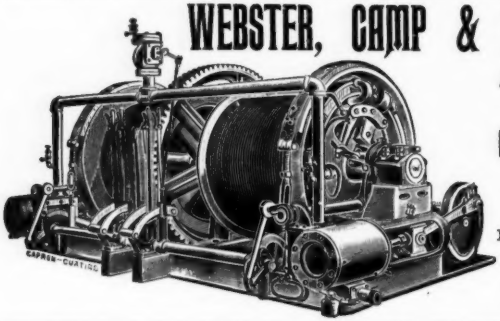

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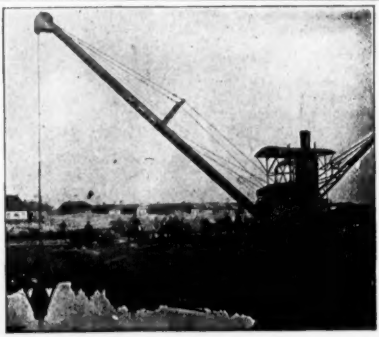

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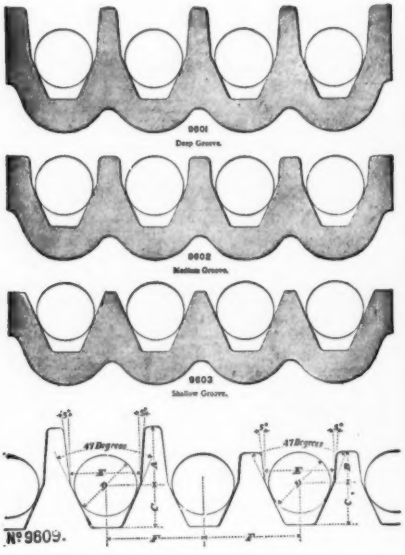

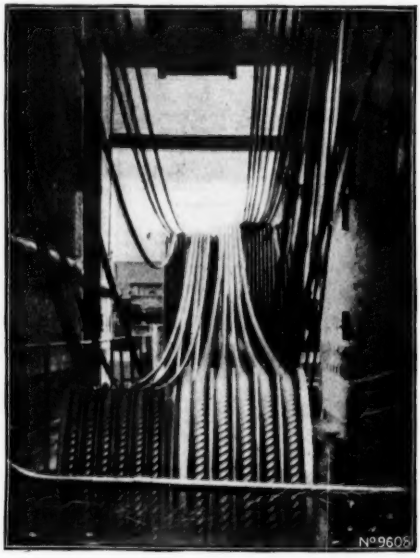

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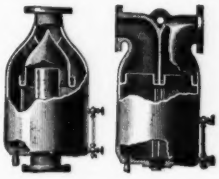

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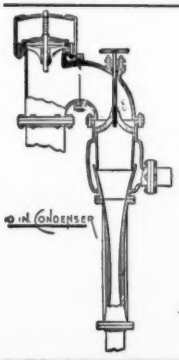

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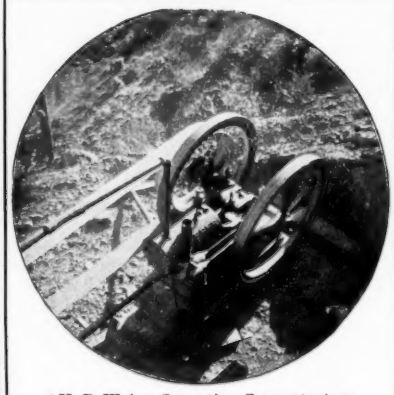

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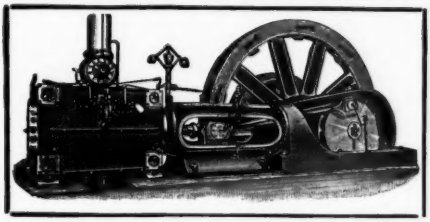

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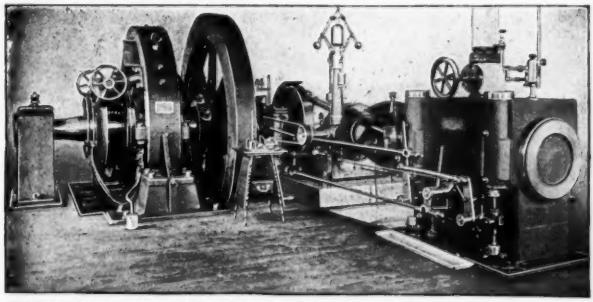

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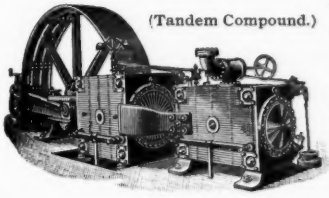

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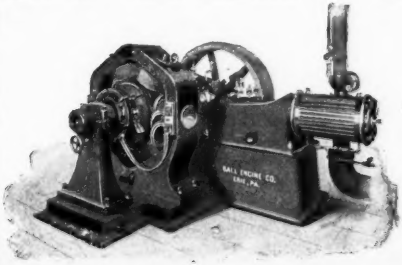

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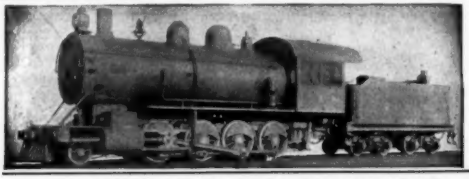

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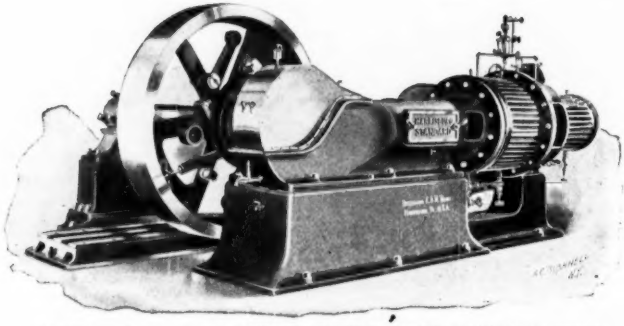

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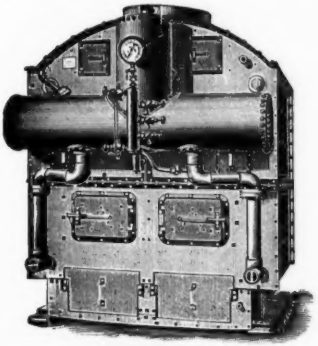

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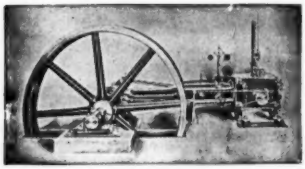

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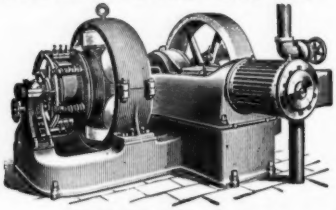

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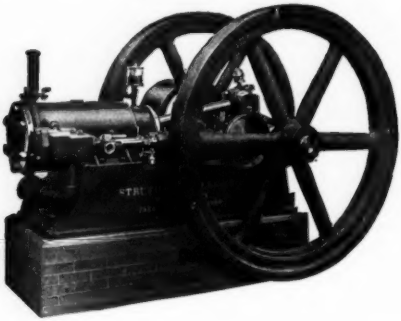

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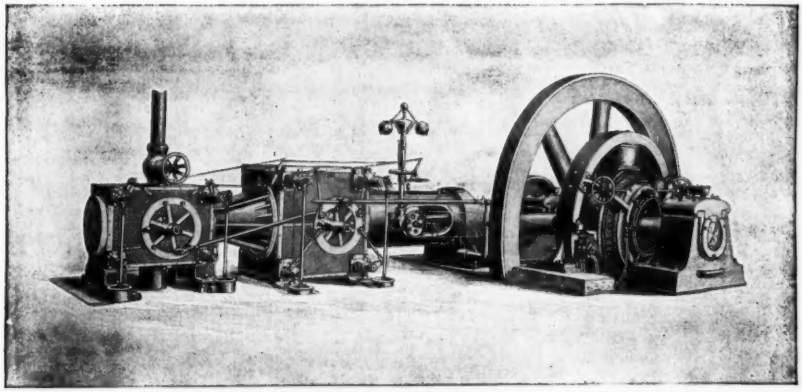

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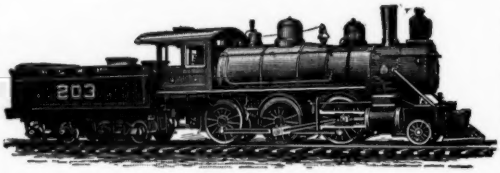

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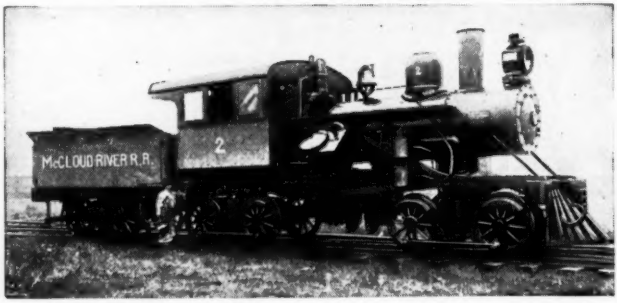

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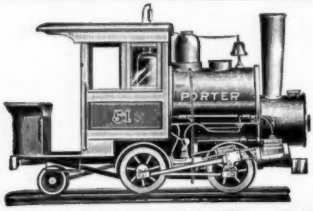

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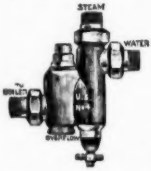

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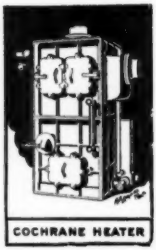
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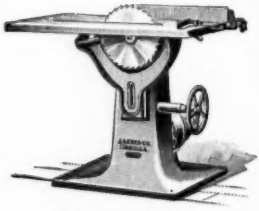

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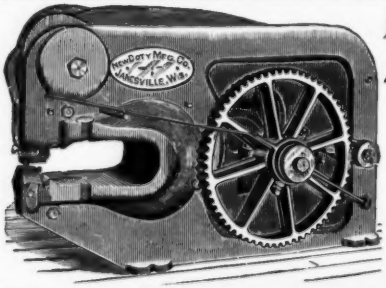

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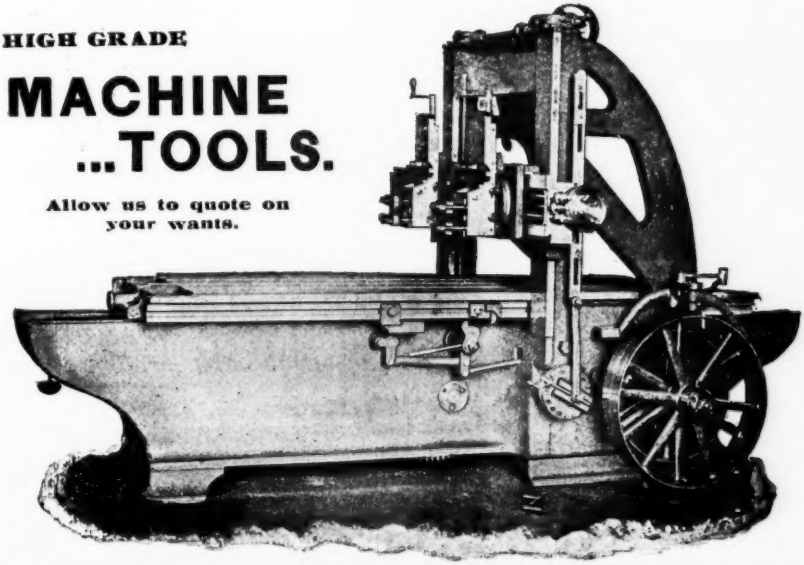

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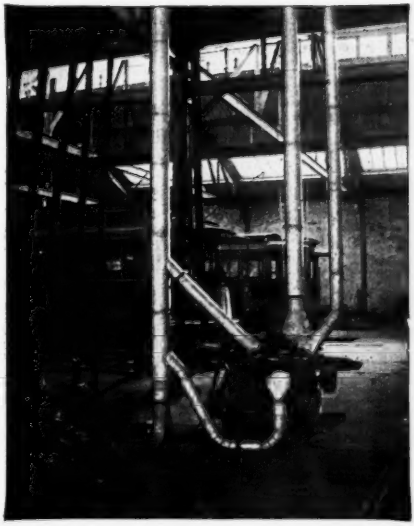

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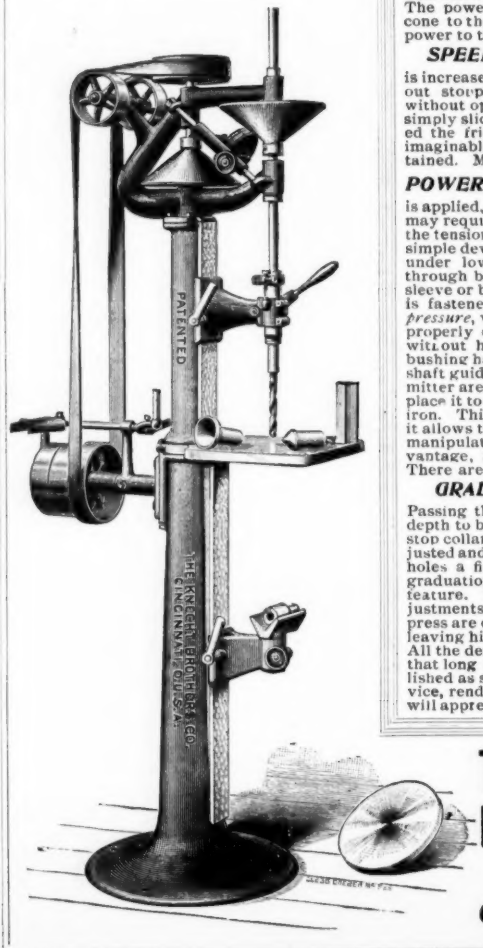

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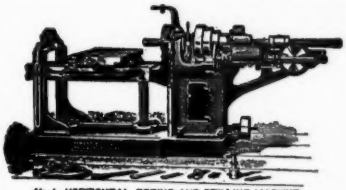

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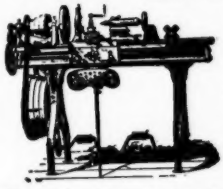

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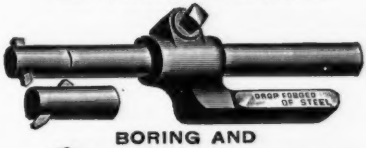

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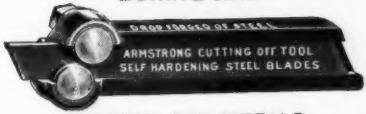

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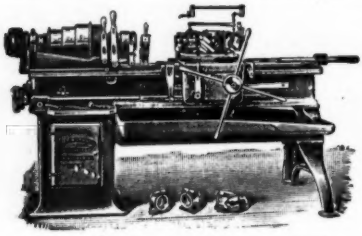

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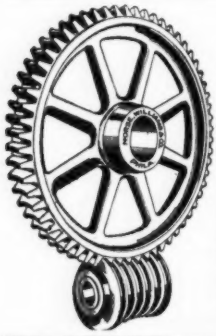

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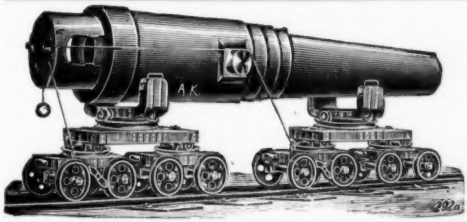

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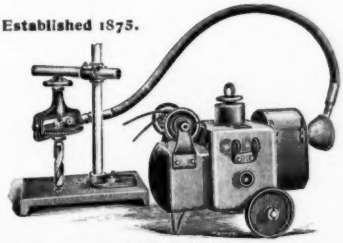

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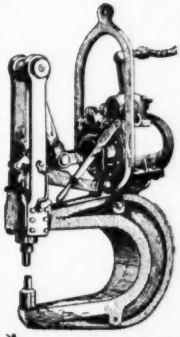

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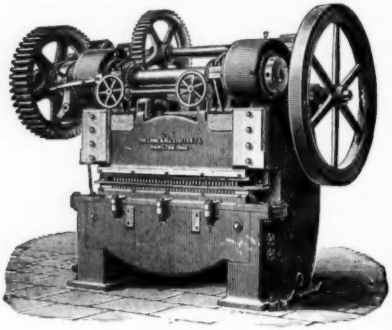
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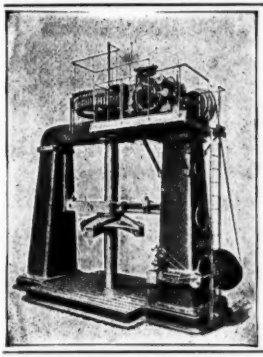

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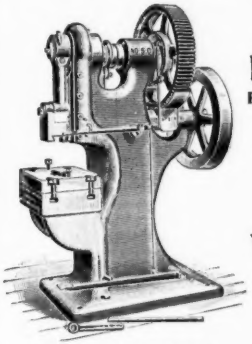

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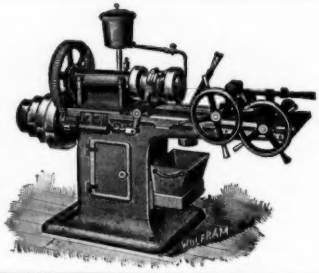

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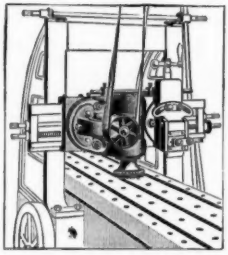

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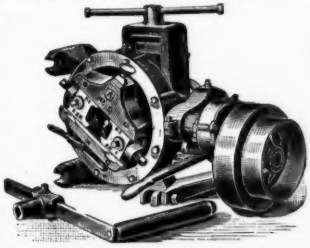

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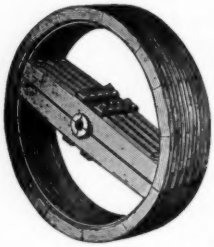

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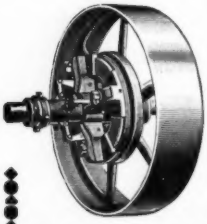

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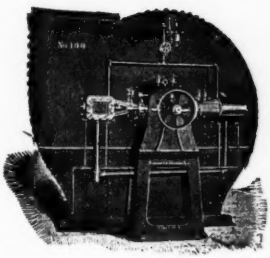

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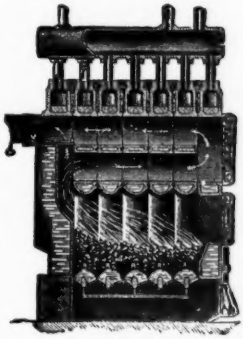

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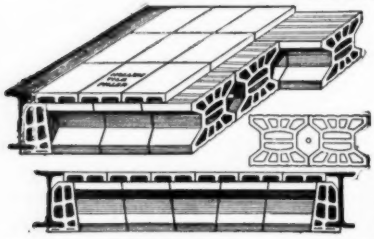

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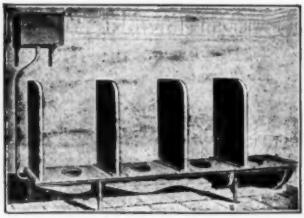

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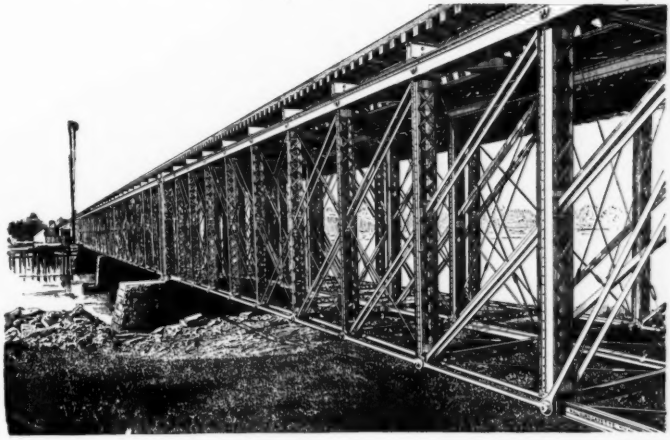

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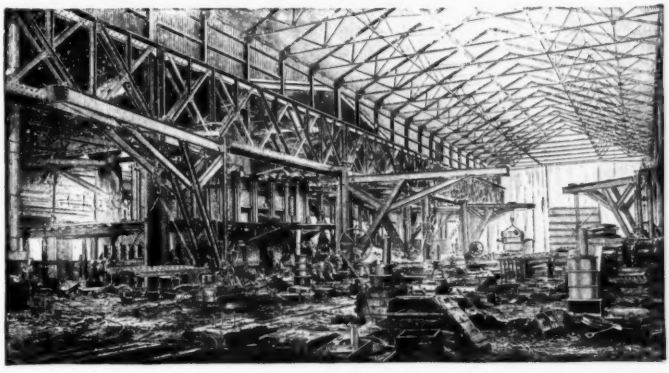

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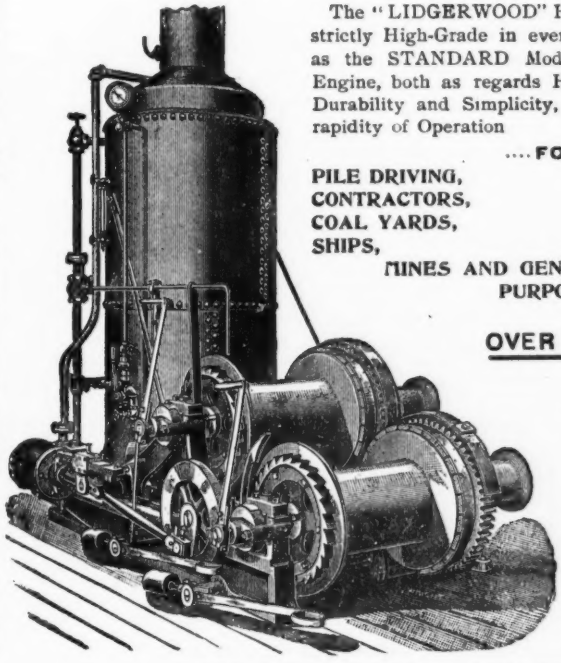

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